LOKTAK
L A K E



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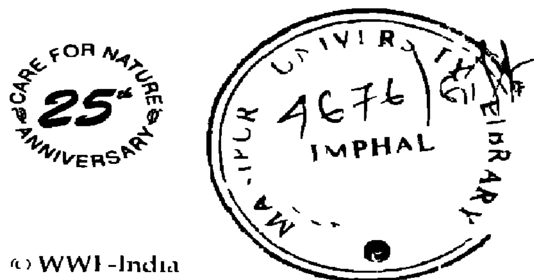


WORLD WIDE FUND FOR NATURE, INDIA

This publication was commissioned by WWF-India (Wetlands Division). It forms a part of a series of publications on the Indian Ramsar Sites funded by WWF-International, Gland, Switzerland.

In the same series

Sambhar Lake, Rajasthan
Keoladeo National Park, Rajasthan
Harike Lake, Punjab
Wular Lake, Jammu & Kashmir
Chilika Lake, Orissa



First Published March, 1994

Citation: *Ramsar Sites of India: Loktak Lake*. H. Tombi Singh and R.K. Shyamananda Singh, WWF-India, New Delhi, 1994

Maps: Virendar Kumar

Design and layout: Akhil Chandra

Published by Avenash Dutta for and on behalf of WWF-India, 172-B, Lodi Estate, New Delhi - 110003, and printed at Dhriti Printers, C-93, DDA Sheds, Okhla Phase II, New Delhi

/94/1000(2)

PREFACE

Loktak lake, rich in biodiversity and the lifeline of Manipur valley, has been recognized as a Wetland of International Importance under the Ramsar Convention since 1990. The essential character of this wetland however changed in 1983 when it was converted into a reservoir due to the construction of Ithai Barrage for hydel power generation and irrigation. Besides altering the hydrology and biota of Loktak, the hydel project has created several problems for the local communities who are dependent on the resources provided by the lake. The unique floating national park, Keibul Lamjao, which forms a part of the lake ecosystem and is the only refuge of the endangered Manipur brow-antlered deer, has also been adversely affected.

Management of the Loktak ecosystem has been a controversial, even contentious, issue. Scientific opinion is itself divided on the management approach and strategies to be adopted. In conflict with scientific opinions, the interests of local communities as well as the Ramsar Convention guidelines, are the grandiose lake development plans under the consideration of the state government's Loktak Development Authority. The divergence of opinions and interests among the various groups has resulted in the absence of a singular acceptable management plan for Loktak as the ecosystem progressively deteriorates and traditional communities continue to suffer the effects of ecological degradation.

As a part of its wetlands conservation programme, WWF-India is bringing out a series of publications on India's internationally important wetlands (Ramsar Sites). This volume, the second in the series, describes the Loktak ecosystem, points out the causes and consequences of human intervention on the system, and discusses various management options. An annotated bibliography on Loktak lake is appended.

WWF-India appreciates the effort put into the preparation of the manuscript by Prof. H. Tombi Singh and Dr. R.K. Shyamananda of Manipur University. We are deeply indebted to Dr. Brij Gopal, School of Environmental Sciences, Jawaharlal Nehru University, for reviewing and redrafting the manuscript upon the request of WWF-India. All credit for data entry and finalisation of the manuscript for production goes to Ms Lata Raman (Research Officer, WWF-India). The generous financial support received for the publication from WWF International is gratefully acknowledged.

1 March 1994

Rashmi De Roy
Programme Coordinator
(Wetlands)

CONTENTS

Loktak Lake

Manipur

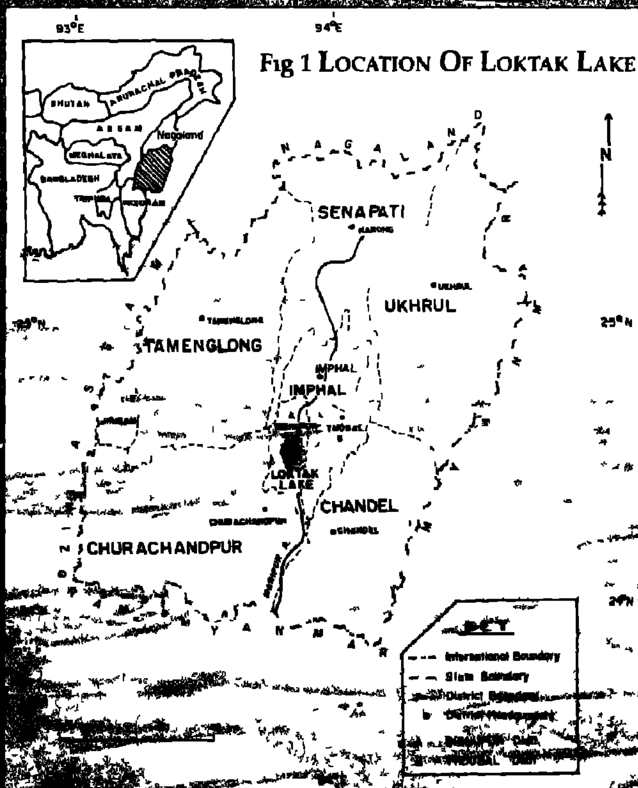


Fig 1 Location Of Loktak Lake

INTRODUCTION

Manipur referred to as the 'Jewel of India', stretches from 23° 83'N - 25° 68'N to 93° 03'E - 94° 78'E in the northeastern corner of the country adjoining Myanmar It is a small mountainous state bound by Nagaland (north), Mizoram and Myanmar (south and east), and Assam (west) Extending over a total area of 22,327 sq km, the state comprises a central valley (average altitude 775 m above sea level) surrounded by hill ranges ascending steeply from 800 m to 3000 m and above The valley, drained by the Manipur river (a tributary of Chindwin river in Myanmar), is largely covered with a number of shallow marshes (locally called phats *or* pats*) which are fed by run off from the surrounding hills The largest of these* phats *is the Loktak lake (Fig 1)*

So heavy is the dependence of local communities on Loktak's resources (food, feed, fibre, fuel and shelter) that it is considered the lifeline of Manipur valley. Floating islands of decaying vegetable matter (*phoomdi*) characterise the lake habitat. *Phoomdi* is most widespread in Keibul Lamjao National Park occupying the southern part of the lake. The park has the distinction of being the only refuge of the highly endangered *sangai* or Manipur brow-antlered deer (*Cervus eldi eldi*). Loktak is also a significant wintering area for a large number of waterfowl from northern latitudes. In recognition of the lake's rich biodiversity and its socio-economic importance, Loktak was designated a wetland of international importance under the Ramsar Convention in 1990.

However, the lake ecosystem has changed considerably over the last decade since 1983 when a multipurpose project was commissioned for hydel power and irrigation. For this a barrage was constructed on Manipur river diverting it into Loktak and thus converting the natural wetland with fluctuating water levels into a reservoir with a more or less constant water level. Besides bringing about basic hydrological changes, this resulted in several problems for the lake biota as well as for the local communities traditionally dependent upon this system. Loktak lake has therefore been placed on the Montreux Record - a list of internationally important wetlands (Ramsar sites) that have undergone or are undergoing significant changes in their ecological character.

THE RAMSAR CONVENTION

The Convention on Wetlands of International Importance especially as Waterfowl Habitat, known simply as the Ramsar Convention, is an intergovernmental treaty which provides the framework for international co-operation for the conservation of wetland habitats. Although the text was adopted in 1971 at the Iranian city of Ramsar, the Convention did not come into force until late 1975. It now has Contracting Parties throughout the world, including India, which acceded to the Convention in 1982.

Wetlands are essential not only for hydrological and ecological processes, but also for the rich fauna and flora they support. This is why the broad objectives of the Convention are to stem the degradation and loss of wetlands and ensure their conservation. In addition to the general obligation of including conservation of the wetland heritage in their land-use planning, governments that are party to the Convention undertake to respect four main obligations:

- to designate at least one wetland for inclusion in the List of Wetlands of International Importance;
- to promote the wise use of wetlands in their territory;
- to consult with each other about implementing obligations arising from the Convention, especially, but not exclusively, in the case of a shared wetland or water system; and
- to create wetland reserves.

Wetlands are selected for the List of Wetlands of International Importance (or Ramsar sites) on account of their international importance established on the basis of ecological, botanical, zoological, limnological or hydrological criteria. Such is the case, for example, of a site representative of a rare or unusual wetland type in a biogeographical region, or of special value for maintaining the biological diversity of a region, or that supports at least 20,000 waterfowl each year. Contracting Parties are obligated to take measures to preserve the ecological character of the listed sites.

Besides Loktak lake, India has five other Ramsar sites: Chilika lake (Orissa), Keoladeo National Park, Bharatpur (Rajasthan), Sambhar lake (Rajasthan), Wular lake (Kashmir) and Harike lake (Punjab).

LOKTAK LAKE AS A RAMSAR SITE

Loktak lake has a number of characteristic features that justify its international status as a Ramsar site

- It is covered extensively by naturally-occurring *phoomdis* which are a specialized habitat for many biota besides being useful to the local people in many ways
- The Keibul Lamjao National Park in the southern part of the lake is a unique floating wildlife reserve and the only home of the endangered Manipur brow-antlered deer or *sangai* with an estimated population of 106 (in 1991)
- It has been the breeding ground of a number of riverine migratory fishes from the Irrawady-Chindwin river system and continues to be vital as a fish habitat
- It is of enormous socio-economic importance for the inhabitants of Manipur valley
- **The lake also supports a significant population of resident and migratory waterfowl**

IDENTIFYING WETLANDS OF INTERNATIONAL IMPORTANCE

A wetland is identified as being of international importance if it meets at least one of the following criteria that were approved at the Fourth Meeting of the Conference of Contracting Parties to the Ramsar Convention at Montreux Switzerland 1990

1 Criteria for representative or unique wetlands

A wetland should be considered internationally important if

(a) it is a particularly good representative example of a natural or near natural wetland characteristic of the appropriate biogeographical region or

(b) it is a particularly good representative example of a natural or near natural wetland common to more than one biogeographical region or

(c) it is a particularly good representative example of a wetland which plays a substantial hydrological biological or ecological role in the natural functioning of a major river basin or coastal system especially where it is located in a trans-border position or

(d) it is an example of a specific type of wetland rare or unusual in the appropriate biogeographical region

2 General criteria based on plants or animals

A wetland should be considered internationally important if

(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal or an appreciable number of individuals of any type or more of these species or

(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna or

(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle or

(d) it is of special value for one or more endemic plant or animal species or communities

3 Specific criteria based on waterfowl

A wetland should be considered internationally important if

(a) it regularly supports 20 000 waterfowl or

(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl indicative of wetland values productivity or diversity or

(c) where data on populations are available it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl

Following a recommendation at the Fifth Meeting of Contracting Parties to the Convention (Kushiro Japan 1993) criteria and guidelines are being developed for identifying Wetlands of International Importance as fish habitats

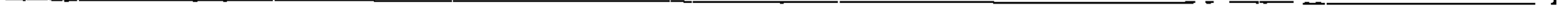
Fig 2 Drainage Basins In Manipur

NAGALAND
ASSAM
MIZORAM
MYANMAR
MYANMAR
Karong
Ukhrul
Tameng-long
Sekmai
Imphal
Thoubal
Bishnupur
LOKTAK LAKE
Chandel
Churachandpur
BARAK RIVER
MAKRU R
IRANG R
R. TUIPUI
R. TUILANG
R. LEIMATAK
RIRING
R. IYEI
IMPHAL R.
IRIL R.
R. THOUBAL
MANIPUR R.

KEY

International boundary
National boundary
Rivers
Lake & swamps
Drainage boundary
(1) Imphal river system
(2) Chindwin " "
(3) Barak " "

0 4 8 12 16 Km



MANIPUR VALLEY

TOPOGRAPHY

The Manipur valley is a more or less flat area of 2238 sq km in the midst of high steeply sloping hills. It slopes gently from north to south from an altitude of 798 m to 746 m. Besides a number of small hills dotting the valley (highest being Karang island 903 m), major physiographic features of the valley are the numerous streams and rivers arising from the hills on all sides and many shallow lakes and marshes in the interfluvial areas (Fig. 2).

CLIMATE

The valley has a moderately cold subtropical monsoonic climate. Rainfall occurs mainly during the south west monsoon period from May to September but the retreating monsoon also brings some rain. One may recognize five seasons — summer (May - June), monsoon (July - September), autumn (October - November), winter (December - February) and spring (March - April). However, the summer and rainy seasons are not clearly distinguished as the summer is not dry. The minimum temperature during the winter drops to 0 C whereas the maximum summer temperature rises to above 36 C. Rainfall is highly variable from year to year, ranging from less than 600 mm to above 1600 mm with an average of 1400 mm (Fig. 3 and 4).

Direct and diffuse solar radiation in the valley averages 290.36 - 780.86 gCal/sq m/day, of which the visible radiation averages 113.05 - 295.37 gCal/sq m/day. The duration of bright sunshine varies from 3 hours on cloudy days to 9 hours on clear days (Tombi Singh and Shyamananda 1988).



Karang island

GEOLOGY

Geologically, the hills in Manipur are quite young as they were formed during the Tertiary Orogeny (2,500,000 - 65,000,000 years ago) of the Himalayas from the shallow bed of the Tethys sea. The rocks around Loktak lake are Tertiary shales of Disang series overlain by those of the Barail series of the Oligocene Period (38,000,000 years ago) which are characterized by the abundance of carbonaceous matter. The valley is filled up by alluvial (unconsolidated) detrita which consists mainly of clay and mud derived from weathering of the underlying argillaceous rocks and from sediments carried by the numerous streams (Fig. 5).

DRAINAGE

The Manipur river arises in the north at Karong. It flows southwards past Imphal, the capital of Manipur and is known as Imphal river. The Imphal river is first joined on its left bank by Iril river at Lilong, about 10 km south of Imphal. Later, Thoubal river also joins it

Fig 3 Mean Annual Rainfall In Manipur Valley

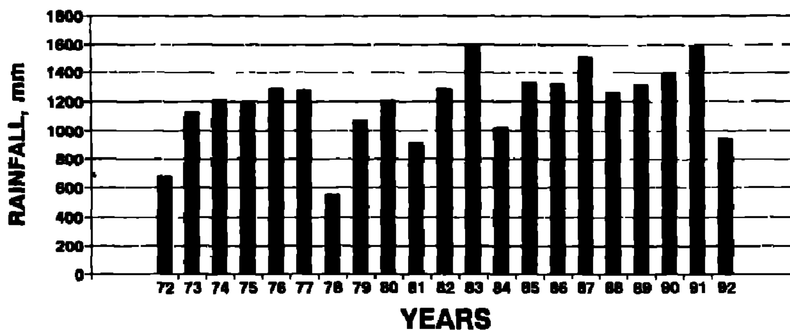


Fig 4 Mean Monthly Temperature And Rainfall In Manipur Valley

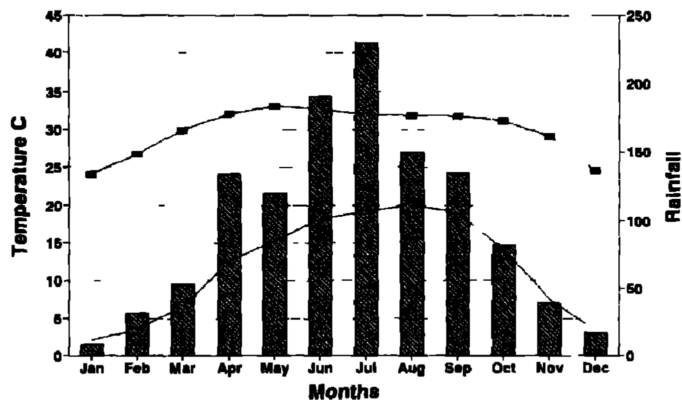
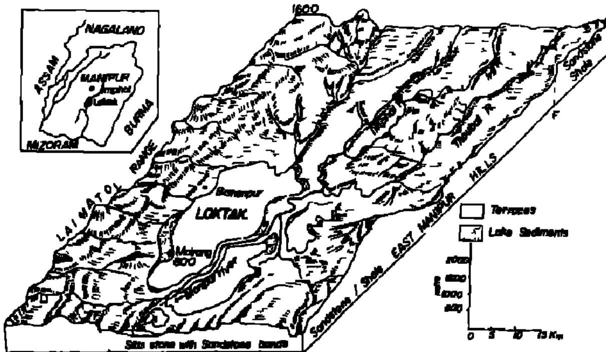


Fig 5 Manipur Valley Topography And Geology

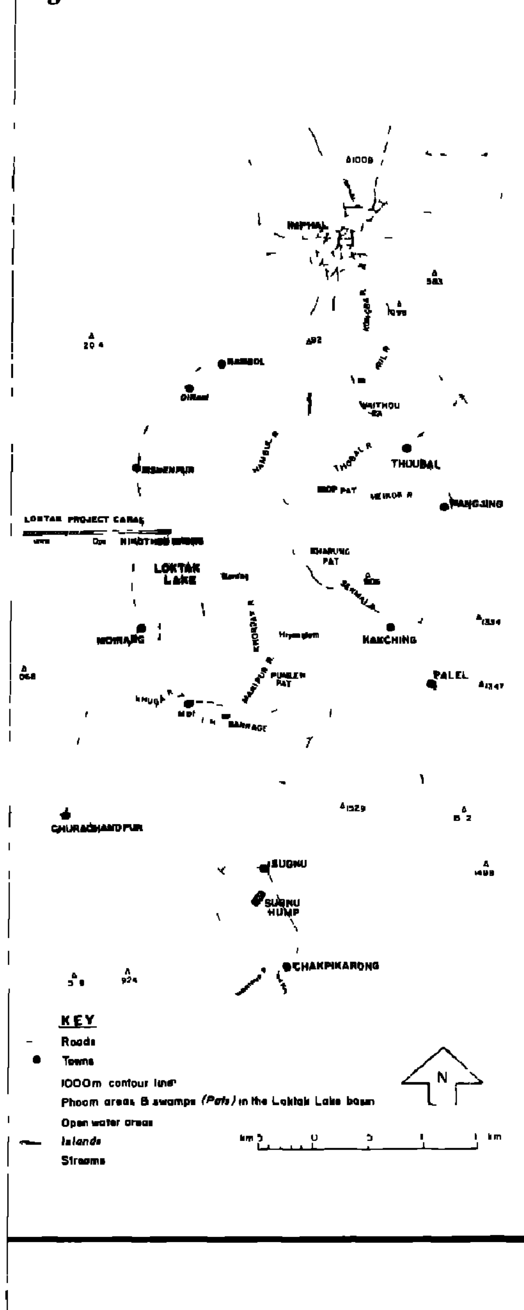


from the left bank at Irong Ichil. After another 10 km, it is joined by Sekmai river near village Sekmaichin, and thereafter, it is known as Manipur river. Further downstream, Khuga river joins the Manipur river on its right bank. Later the Manipur river flows south through a narrow gorge and undulating terrain for about 26 km where it meets the north flowing Chakpi river near village Sugnu. It continues flowing south into Myanmar where it joins the Chindwin river— a tributary of the Irrawady river.

There are several shallow lakes or marshes locally called *phats* or *pats* in the interfluvial areas. Thus there is Lamphel *phat* between the rivers Nambul and Imphal, Waithou *phat* between the rivers Iril and Thoubal, Ikop *phat*, Kharung *phat* and Lousi *phat* between Thoubal and Sekmai rivers and Khoidum Lamjao and Pumlen *phats* south of Sekmai river. On the west between the rivers Manipur and Khuga lies the Loktak lake which comprises about 20 small and large *phats* (Appendix I A). Of which Loktak, Lakmu, Unamen, Laphu, Thamnumacha, Khulak, Yena and Tharopokpi are fairly large (more than 80 ha). Two other *phats* just north of Loktak lake are Sana *phat* and Utra *phat*. During the rainy season most of these *phats* become contiguous and merge under a large sheet of water but can be distinguished separately during the dry season at a water level of about 766 m above mean sea level (MSL) (Fig 6).

Several small rivers and streams rising in the surrounding hills drain into these *phats* on both sides of the Manipur river. The Nambul river and Nambol river are two major streams from the north flowing into Loktak basin. Besides these there are over 34 small streams draining from the hills on the west into the Loktak basin (Appendix I B, Fig 7). Loktak lake is connected to Manipur river by a small channel (about 15 m wide and 6 m deep) called Khordak cut which drains the lake into the river during the dry period. However when the river is in spate it backflows into

Fig 6 LOKTAK LAKE AND ITS SURROUNDINGS



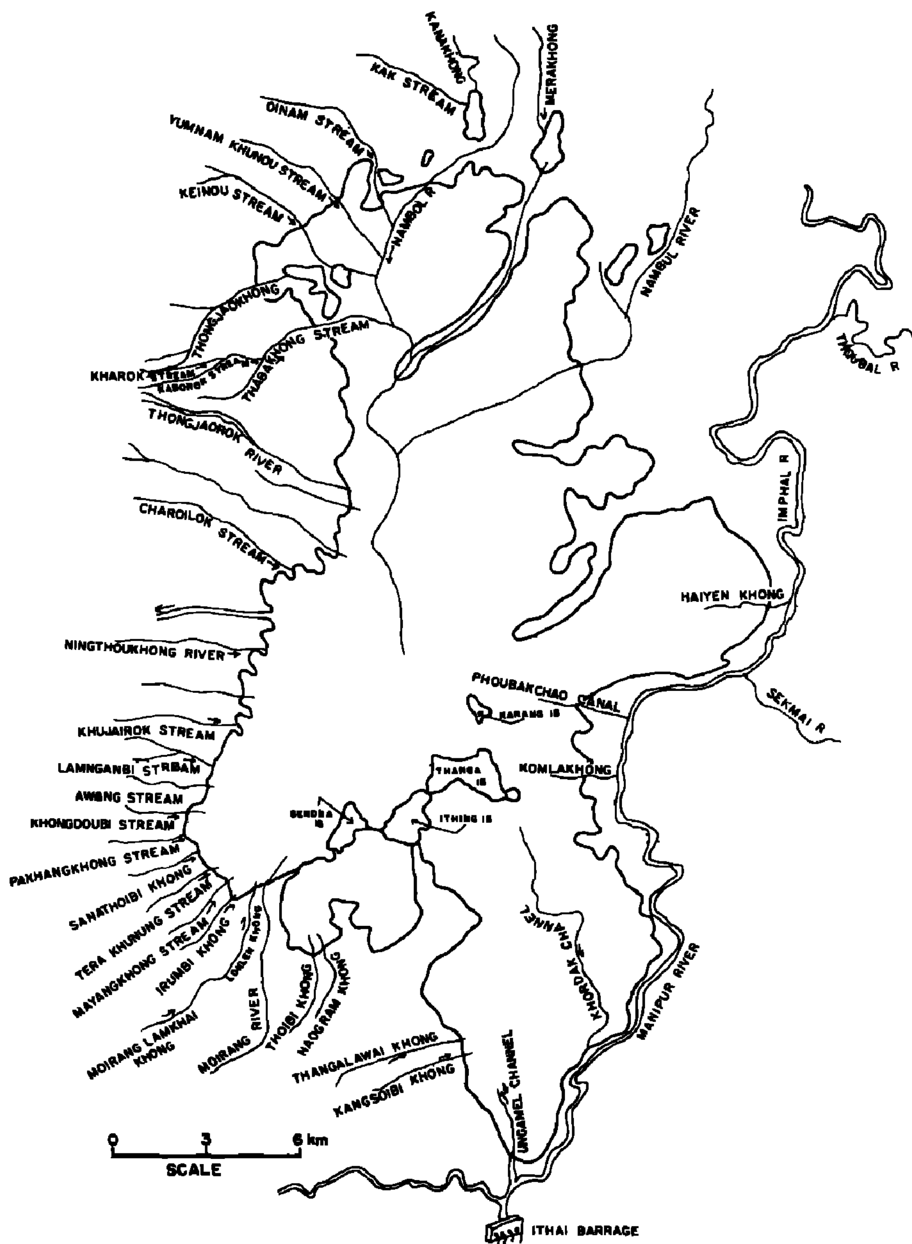


Fig 7 Feeder Streams And Outlets Of Loktak Lake

the lake through the channel. Similarly, the Pumlen *phat* is also connected to the Manipur river by a narrow channel, the Marambakhon, which also allows flow both ways. Thus, during the period of high flood (as was seen in 1966) a large part of the valley on both sides of the Manipur river becomes one large lake.

RIVER REGULATION

Along its course through the valley, downstream of Imphal, the river bed slopes very gently. The bed level is 773 m at Imphal and 768.6 m at Lilong (near its confluence with Iril river) but rises slightly to 771 m before falling again to 762 m at Ithai, downstream of the confluence of the Manipur and Khuga rivers, about 6[illegible] km south of Imphal. Notwithstanding the gentle slope, the river has been regulated by two barrages for irrigation and hydel power. First, the Imphal barrage downstream of Lilong regulates the flow for the purpose of irrigation (about 6000 ha area). The second barrage, constructed in 1976 at Ithai, diverts the river flow into the Loktak lake for lift irrigation and a hydel power project.

An interesting and hydrologically important feature of the Manipur river is the natural blockage of its flow in its lower reach. About 27 km downstream of Ithai barrage, after sloping down to 756.7 m, the river bed suddenly rises by 8 m within a distance of 800 m and remains above 762.5 m for about 2.5 km. This rocky barrier to the flow is known as Sugnu hump (named after Sugnu village, Fig. 6). It reduces the capacity of the Manipur river to discharge its flow. At the same time, Chakpi river drains a large part of the southern valley and meets the Manipur river just upstream of Sugnu hump. As the Manipur river flows at its full capacity during the rainy season, it acts as a barrier for the Chakpi river. On the other hand, sometimes the Chakpi river discharges into Manipur river earlier in the season, thereby creating an obstruction to the flow from the upstream areas. Thus, during the rainy season, the excessive flow of both Chakpi and Manipur rivers spread backwards flooding large areas of the valley. The situation has become worse since the construction of the Ithai barrage.

Loktak Lake

Origin Of The Lake

Our knowledge of the geology of Manipur is grossly inadequate to decipher the origin and evolution of Loktak lake with certainty. The isotopic data of the lake sediments suggest that it existed from the middle of the last glacial period about 25,000 years ago (Vishnu-Mitre 1986). Several views have been expressed about its origin and evolution.

According to a legend, Manipur valley was once submerged under water and surrounded on all sides by the hill ranges. Lord Shiva created the central valley by draining the water through a tunnel drilled by his trident in the southern hill. Another legend traces the earliest human settlements on top of the surrounding high peaks (like Nongmai-ching hill 40 km north of Imphal, and Koubru hill 60 km north-west of Loktak lake) when the valley remained a vast sheet of water. Downward human migration into the valley started as the water receded in the course of time.

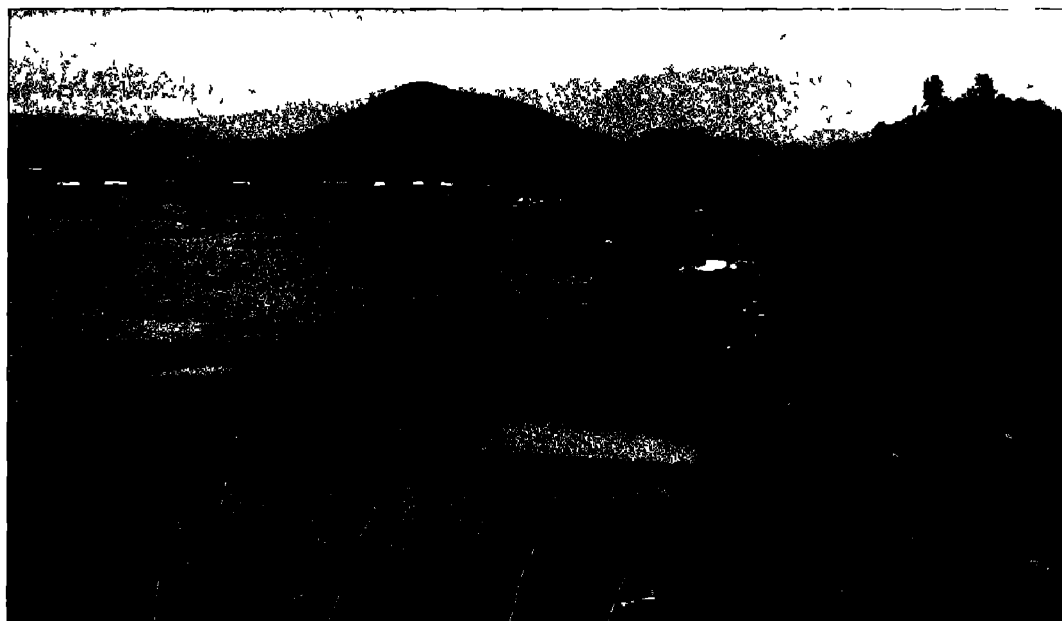
According to a theory supported by Dune (1836), the valley was formed by the depositions of a stream that was blocked by some convulsions of the earth's crust. This view is supported by the present landforms of the valley. The formation of the valley may be closely associated with the upliftment of south Manipur hill and subsequent downcutting of the area, by Manipur river and its tributaries, draining the present area of Manipur valley.

A view supported by Bhatia (1979) states that the present valley came into existence as a result of gradual siltation by sediments brought by the rivers.

Johnstone (1971) suggests a compromise between the riverine and lacustrine origins. According to him the Manipur valley was once a series of valleys and small hill ranges between the higher ranges which still border the valley. Rivers presently flowing in the valley would flow through small hill ranges and valleys of that time. A great earthquake closed the outlet of water making a permanent barrier and formed a big lake. In due course a plain was formed to fill up the gaps between the small hill ranges in the central part which subsequently became the central valley leaving Loktak lake in its lowest part.

This view is supported by the land forms. Whereas the hills in the Loktak basin are the likely remnants of small hill ranges in the valley, the Sugnu hump arose probably from tectonic activity. Lithologically, the valley represents the axial region of an anticlinorium, the weak crest of which has been eroded. The erosional environments of the past in the valley have been studied in geomorphological and palynological perspectives by several workers (Mukhopadhyay 1988, Ray and Chanda 1989). Fluviolacustral sediments are encountered in many parts of the valley to a depth of 152 m below ground level. At the same time black clay of lacustrine origin is exposed upto 40 m above the present water level of the Loktak lake. A few C^{14} data on carbonised samples from Lamphel *phat* near Imphal (at a depth of 0.35 m to 0.4 m) and the Loktak hydel project area on the western shore of Loktak lake (at a depth of 5.3 m to 12 m) indicate that the age of the central and southern parts of the valley ranges from 7980 - 470 BP* to 25,000 - 600 BP. Thus it could be

* *Before Present*



Linear settlement and fish culture ponds along Thanga and Ithing islands

inferred that a considerable vertical change in the lake water level has occurred in the valley.

Thus, the origin and evolution of Loktak lake may be ascribed to tectonic activity and neotectonism remarkably influenced by a long history of fluviolacustral processes. It is reported that the Manipur valley remained free from Pleistocene glaciation. During the Quaternary the valley had an anastomosing system of drainage channels interspersed with a number of standing water bodies.

Catchment

Loktak lake has a total catchment area of 980 sq km most of which is either hilly or heavily populated. Most of the population of the Manipur state lives in the valley. The catchment includes 16% area in the western hills under forest cover and 68% area under agriculture— both shifting and extensive. The settlements cover about 16% (13% rural and 3% urban). However WAPCOS* (1988) has estimated 230 sq km of forest cover (170 sq km protected forest and 60 sq km reserved forest) and 430 sq km under paddy fields besides the settlement area. Indirectly the catchment area of Loktak lake may be considered to include the total 3820 sq km catchment of Manipur river and its tributaries mainly the Iril, Thoubal, Sekmai and Khuga rivers because their waters enter the lake (only occasionally in the past) due to Ithai barrage through Khordak channel.

There are 55 rural and urban settlements around the lake (Fig. 8). The total human population on and around the lake is estimated to be about 100 000, of which about 30 000 are fishermen. The natural levees of Manipur river and its tributaries are densely inhabited. The linear settlements extend to the narrowest parts (50 m - 100 m wide) of the levees and are close to the water

* Water and Power Consultancy Service (India) Ltd

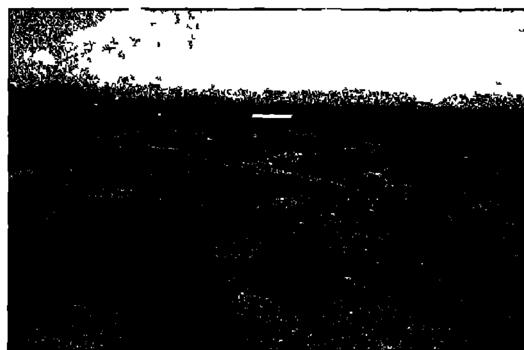
Fig 8 Settlements On And Around Loktak Lake

level. In fact, the houses are made on stilts right into the marginal areas of the lake. A large number of fishermen also live on the Thanga, Karang, Ithing and Sendra islands. Further, a large population of fishermen lives on some 1,500 floating hutments many of which have now been converted into permanent dwellings. There are also some hutments in the Keibul Lamjao area.

The two major landuses in the catchment are shifting cultivation in the forests on the hills and paddy cultivation in the valley. The hills are largely under the control of tribal chieftains who regulate the shifting cultivation. A major portion of the catchment is already considerably denuded. It is estimated that nearly 50 sq km of forest is subject to shifting cultivation every year. It involves felling, clearing and burning of vegetation on the hill slopes, dibbling, sowing, weeding and harvesting the crop. In the past, shifting cultivation was practiced in a cycle of 15-20 years allowing enough time for regeneration of the forest after a harvest, but in recent years the cycle has been reduced to 3-6 years due the population pressure and reduced fertility of the land.

Paddy is the main crop cultivated in the valley. The paddy fields are often contiguous with the lake margins. Before the lake became permanently flooded, cultivation was extended to the whole of the exposed lake bed. Intensive fish culture has also begun in recent years in some areas on the periphery of the lake. Though there is no industrial activity in the catchment, mining of stream banks for sand and gravel is common. All these landuse practices promote erosion causing loss of soil and nutrients which readily find their way into the lake.

It may be noted that before Loktak lake was converted into a permanent reservoir, the entire lake bed exposed during the winter was cultivated with winter crops. The shallow water bodies which remained were used for cultivation of *Furyah* (fox nut) and the ridges between different *phats* were occupied by hutments.



Sand and pebbles quarrying operations on the Thongjaorok river bed. The river flows from the western catchment and carries enormous quantities of silt into Loktak lake.

THE LAKE ECOSYSTEM

Loktak lake (93°46'-93°55' E; 24°25'-24°42' N) comprises several smaller lakes or *phats*. Until 1983, the area used to experience large water level changes during the year so that several lakes were separated during the low water phase and merged into one lake only at the time of high flood. Since the commissioning of Ithai barrage in 1983, it is a permanently flooded lake with relatively small water level changes regulated by the withdrawal of water for hydel power generation. There is, however, not much information on each of these lakes. Only a small part of Loktak lake (Takmu sub-basin and a few adjacent parts) have been investigated earlier during 1977-79 (Bhatia 1979). Detailed studies have been undertaken only recently (Shyamananda 1991) and therefore the following account refers to the lake as one basin with occasional references to other *phats* as sub-basins. Interestingly, the lake basin was not adequately surveyed in the planning of the Loktak Multipurpose Project which relied on the study made by the Survey of India in the 1960s. The altitudes demarcated during that survey (as noted by the bench marks) were shown to be higher by 1.03 to 1.89 m due to some error and therefore the earlier records of

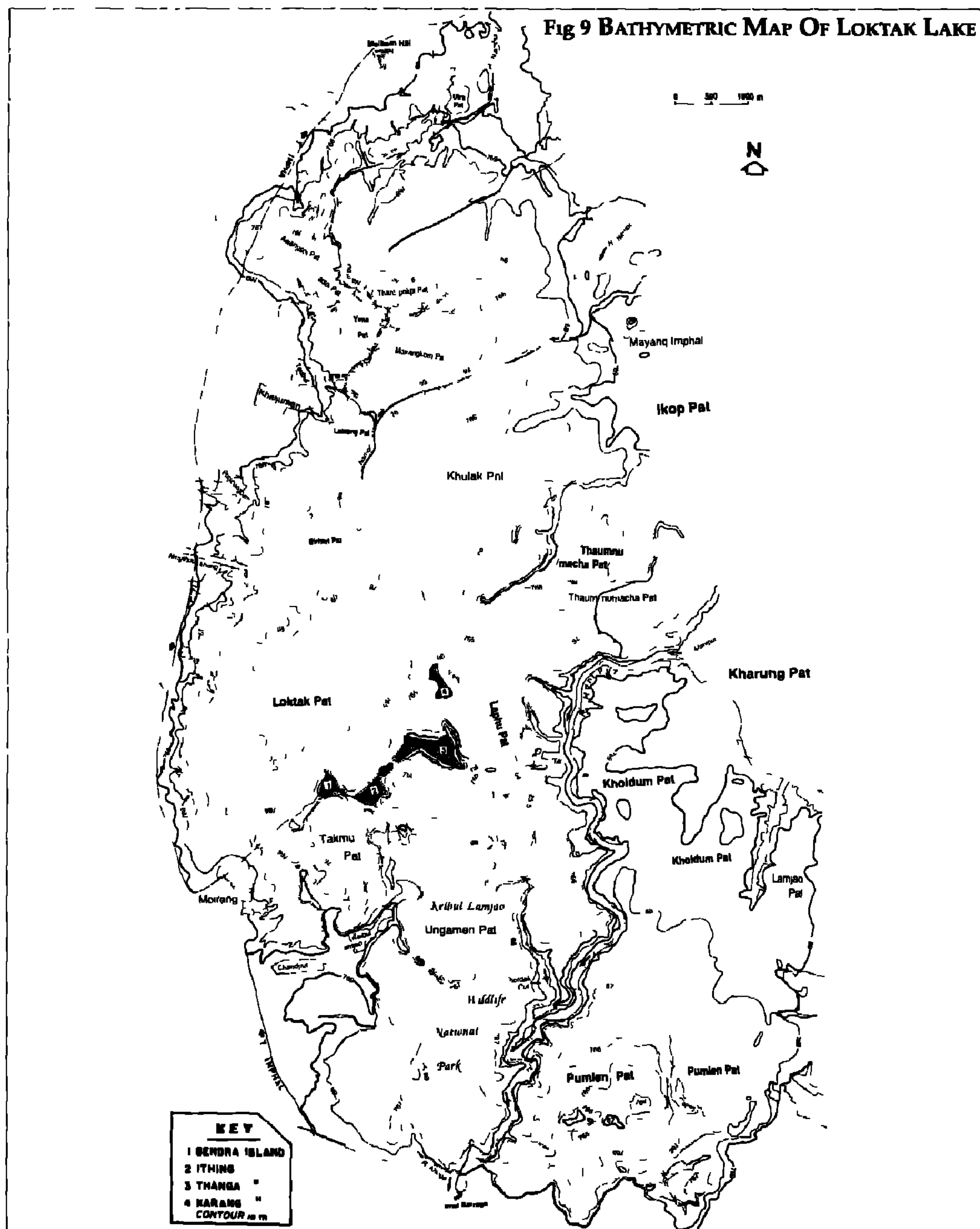


Fig 9 Bathymetric Map Of Loktak Lake


LOKTAK
LAKE
BISHNUPUR
WANGOI
TOP
KHANGABOK
SEKMAI R
HIYANGLAM
LAIMANAI
MOIRANG KHUNOU
ITHAI
BARAGE
KWASIPHAI

KEY

HILLS

water level and floods are of little help. It is reported that during 1966 the floods touched the 771.83 m mark which would have been only about 770 m in view of this error!

Morphometry

The lake is somewhat oval in shape with its long axis running north to south. It has a maximum length and breadth of 26 km and 13 km respectively. The surface area, at 768.5 m water level (full pond level of Ithai



Ithing and other islands against a backdrop of Thangjing Range which forms part of the Loktak catchment to the southwest

barrage) is 288.96 sq km. At full capacity the lake has a slightly irregular shoreline. The mean depth is 2.07 m. Before the hydel project was commissioned, Loktak lake referred to as Loktak *Phat* (now the main sub-basin) had an area of only 55 sq km with an average depth of 1.19 m. The maximum depth of 4.58 m is now recorded only in the Loktak *Phat* and Laphu *Phat* subbasins (Fig. 9). Other morphometric data are given in Table 1. More than 80% of the total area is less than 3 m deep and only about 3% of the water storage lies in the over four metre deep area (Tombi Singh 1992). It may be pointed out that the estimates of the surface area have differed greatly in the past according to the period of survey when the water levels were low or very high. The surface area had been estimated at 390 sq km at a time when high floods made the Loktak basin contiguous with the Pumlen and other *phats* on the east of Manipur river (Panwar 1979).

There are 14 hills varying in size and elevation appearing as islands in the southern part of the lake. The most prominent of them are Sendra, Ithing and Thanga islands which run southwest to northeast between the main Loktak *phat* and Takmu and Ungamen *phats*. North of Thanga is the Karang island which is the highest (903 m) in the area. Other smaller islands lie mostly in the Ungamen *phat* area better known as Keibul Lampao. These islands cover about 17.2 sq km of the surface area of the lake.

Another important feature of the lake are the numerous floating islands composed of partly decayed organic matter and soil overgrown with aquatic and terrestrial vegetation. The floating islands are called *phoomdis*. The Keibul Lampao area of the lake is covered by a large single thick mat of *phoomdi*. Thus only about 65.25 sq km i.e. less than a fourth of the total surface area of the lake surface is an open water area.



Organised fishing called 'Hi Yeiba' in an open water *phoomdi* free area of the lake

During the past two decades several physical changes have been made in the morphometry of the lake basin for getting better access to its different parts. The construction of Moirang-Sendra and Keibul-Thanga causeways have completely separated the Takmu sub-basin from the main Loktak lake. Recently the Bishenpur-Mayang Imphal road has been completed across the northern part of the lake. The construction of numerous fish farms on the periphery of the lake, rapid proliferation of the floating hutments for midwater settlement (of more than 1 500 hutments), and the construction of Ithai barrage have led to significant morphometric changes in the the lake.

No	Parameter	Value
1	Maximum length(l)	26 0 km
2	Maximum Effective Length (l_e)	22 6 km
3	Maximum Breadth (b_e)	13 0 km
4	Mean Breadth (b)	11 1 km
5	Shoreline Length (L)	126 0 km
6	Orientation	N S
7	Shoreline Development (D_l)	2 09
8	Surface Area (A)	288 96 sq km
9	Area covered by phooms	206 51 sq km
10	Area covered by Islands	17 2 sq km
11	Area of open water	65 25 sq km
12	Total volume (V)	598 36 M m^3
13	Maximum Depth (z_m)	4 58 m
14	Mean Depth (z)	2 07 m
15	Mean Depth Max Depth ratio (z z_m)	0 452
16	Development of volume	1 356
17	Area of catchment	980 0 sq km
18	Surface Area to Catchment Area Ratio	0 295

Table 1 Morphometric data of Loktak lake (water level regulated at 768 5 m above MSL)

Source Shyamananda (1991)



The causeway connecting Sendra Island to Moirang town on the mainland. The increasing number of causeways on the lake are obstructing the water flow and encouraging human encroachment

Water Quality

The physico chemical characteristics of lake water were investigated at a few spots near Takmu basin during 1977 79 (Bhatia 1979) and more recently at several other places by Shyamananda (1991). However these data are not comparable because of the vast change in the nature of the lake itself. Further the large variation in the depth, the influence of the discharge from the Nambul and Nambol rivers in the north and numerous hill streams on the west and above all the presence of a large number of floating islands of vegetation result in great spatial and temporal variations in different characteristics. Therefore only a few general features are given below on the basis of recent studies (Shyamananda 1991 Tombi Singh 1992)

The water temperature varies from 8 C in December/January to 32 7°C in May/June with an annual mean of 25°C on the surface and 24°C at the bottom. There is no distinct thermal stratification of water. The turbidity is relatively very low as the Secchi disc transparency averages 80 cm during the rainy season (June/July) and is higher (about 150 cm) during the winter (January/February). The lower transparency during the rainy season is caused by the heavy load of

silt entering the lake with runoff. The transparency remains low during April and November due to the planktonic growth.

Electrical conductivity varies seasonally from 83 µS/cm in the winter to 300 µS/cm in the summer. The pH remains near neutral for most part of the year but acidic conditions (pH upto 5.0) are often recorded. The pH increases slightly during the winter and spring (upto 7.4). Much higher pH values were recorded earlier in the late 1970s (Bhatia 1979). The water at the bottom has a lower pH than at the surface.

The dissolved oxygen (DO) content varies greatly in different parts of the lake and in different seasons (1.5 mg/l to 5.5 mg/l) but totally anoxic condition is never obtained. The DO content of the water at the bottom is in general lower than that of the surface water. The free CO_2 concentration ranges from 1.8 ppm at the surface in the open water area to 19.8 ppm in the bottom waters of Keibul Lamjao National Park area. Free CO_2 is generally more in the bottom waters. No carbonate or phenolphthalein alkalinity has been observed. However, methyl orange or bicarbonate alkalinity ranges from 0 to 56 ppm at the bottom in the open water area of the lake. Seasonally, it decreased during the winter. Bicarbonate alkalinity has not been detected in the southern part of the lake near Keibul Lamjao.

The BOD (biological oxygen demand) of the lake water varies widely in different areas, different seasons and different strata of the water column. In the open water area, the BOD value ranged from 1.8 ppm in June to 6.3 ppm in October at the surface, and from 5.3 ppm in June to 8.2 ppm in August at the bottom. In the macrophyte dominated areas (near Keibul Lamjao) the BOD ranged from 16.3 ppm (in June) to 22.7 ppm (in October) at the surface, and from 18.2 ppm in June to 26.1 ppm in October at the bottom. The relatively high BOD of the lake water is largely due to the continuous addition of large amounts of organic matter (both dissolved and particulate) from the numerous *phoomdis*. The lower DO content of water under the *phoomdis* retards the rate of decomposition and contributes further to the high BOD. In fact, the BOD is highest (corresponding with lowest DO) in the Keibul Lamjao area dominated by a thick cover of floating *phoomdis*.

The silt and undecomposed organic matter from the *phoomdis* cause the high solid content of the lake water. The total solids content ranges from 150 mg/l (in May) to 860 mg/l (in October) in the surface water and from 260 mg/l (in May) to 970 mg/l (in October) in the bottom waters. The values are much higher in the macrophyte dominated zone (from 360 mg/l to 940 mg/l). Of this, the suspended solids alone contribute from 30 mg/l (at the surface in May) to 580 mg/l (at the bottom in October).

The chloride content is very low and exhibits little seasonal change (4.3 ppm in July to 9.3 ppm in March). There is no difference between the surface and bottom layers of water. The silicate content varies from 2.8 ppm to 8 ppm, with slightly higher values in the bottom waters than in the surface waters. The silicate content declined in the spring and autumn in the open water areas but remained uniformly low in the macrophyte dominated areas. These variations were directly related with the growth of diatoms in the spring and autumn seasons in the open waters.

During 1985-86, the calcium concentration ranged from 10 ppm to 26.3 ppm whereas the magnesium concentration ranged from 6.8 ppm to 18.3 ppm. Both calcium and magnesium concentrations were higher in the macrophyte dominated areas than in the open waters. Thus, in terms of total hardness, Loktak lake is a soft water lake.

The total nitrogen concentration ranges from 0.113 ppm to 0.930 ppm with higher values in the macrophyte

dominated areas. The concentration is higher in the spring (0.930 ppm) and autumn (0.626 ppm) seasons than during the summer and winter. The nitrate-N ranges from 0.03 ppm to 0.385 ppm whereas the nitrite-N is rarely recorded (0.02 ppm) in the macrophyte dominated areas. The ammonia-N concentration varies from 0.03 ppm to 0.293 ppm but is very low in the winter. Generally, the ammonia-N concentration is higher at the bottom particularly so in the macrophyte dominated areas. The dissolved inorganic phosphate phosphorus (DIPP) concentration ranges from 5 to 65 µg/l. The total phosphate phosphorous (TPP) concentration varies from 64 to 265 µg/l. Both DIPP and TPP are higher in the bottom waters than at the surface, and also in the macrophyte dominated areas than in the open waters. Seasonally, the concentration peaks in the spring and autumn seasons.

Thus, Loktak is a shallow, wind swept and polymictic lake with slightly acidic soft waters. Its nutrient levels are controlled by the growth and decay cycles of the vegetation of numerous *phoomdis* which dominate the surface.

Sediments

The bottom sediments of the lake are black in colour, soft in nature and highly clayey in texture (60-80% clay content).

Biological diversity

The relatively shallow Loktak lake with a fairly well developed shoreline, numerous floating *phoomdis* and several large and small islands offers a large variety of habitats which ensure a very high biological diversity in the area. Its geographical location and connection with the Chindwin river in Myanmar further contribute to the richness of biota. The floating *phoomdis*, particularly the large floating mass of Keibul Lamjao National Park also support a large number of terrestrial plants and animals contributing significantly to the biodiversity of this important wetland.



Profuse growth of submerged vegetation around a circle of *phoomdi* in a shallow part of the lake

Macrophytes

The aquatic macrophyte flora comprises 233 species (Appendix II A.) representing all growth forms: submerged, free floating, floating leaved and emergent. More common aquatic plants include species of *Ceratophyllum, Hydrilla, Potamogeton, Vallisneria, Pistia, Eichhornia, Monochoria, Salvinia, Trapa, Euryale, Nelumbo, Nymphaea, Alternanthera, Colocasia, Scirpus, Cyperus, Nymphoides, Phragmites, Oryza, Zizania* and *Polygonum*. Among other major species dominant on margins and on *phoomdis* are *Saccharum, Erianthus, Setaria, Alpinia* etc.

Since the commissioning of Loktak hydel project in 1983, some species such as *Trapa natans, Nymphaea* sp., *Nelumbo* sp. and *Euryale ferox* have almost disappeared due to the constantly high water level in the lake.

Phytoplankton

Though some observations have been recorded earlier (Bhatia 1979), detailed studies were made by Shyamananda in 1985-86 (Shyamananda 1991). The phytoplankton comprises 12 species of Chlorophyceae, 10 species of Myxophyceae, 7 species of Bacillariophyceae and 3 species of Euglenophyceae (Appendix II B.). Some species such as *Microcystis, Merismopedia, Oscillatoria* and *Scenedesmus* occur throughout the year. The phytoplankton populations increase in general during the late spring.

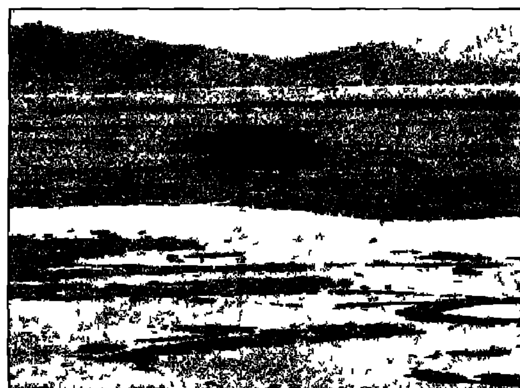
Phoomdi: A special feature of Loktak lake

A characteristic feature of the Loktak lake are the numerous floating islands locally known as *phoom* or *phoomdis*. They are a heterogenous mass of soil, vegetation and organic matter in different stages of decay. They occur in all sizes, some small and others very large and vary in thickness from a few centimetres to about 2.5 m. They occupy nearly two-thirds of the



The edible plants *Trapa natans* and *Euryale ferox* growing in the shallow waters of a weed free part of the lake

surface area of the lake. The largest and nearly contiguous mat of *phoomdi* forms the Keibul Lamjao National Park in the southern part of the lake (south of Thanga island). A recent survey in 1991 estimated that about 206.51 sq km area of the lake's water spread is covered by *phoomdis* (including the Keibul Lamjao) [Fig. 10].



Pabotching hillocks surrounded by *phoomdi* in the Keibul Lamjao National Park

Many different kinds of plants take part in the formation of *phoomdi* but those of primary importance are certain large grasses and sedges and other emergents that give out long floating rhizomes and runners with upright shoots. Free-floating plants such as water hyacinth and partly decomposed roots and rhizomes contribute greatly to their development. A *phoomdi* may be initiated with a small mass of

undecomposed organic matter or dense growth of water hyacinth which accumulate some suspended silt and are gradually colonised by grasses and other herbaceous plants. Later, as more and more organic matter is added from the death and decay of vegetation on and around the *phoomdis* and the mineral soil accumulates from the suspended silt load, the *phoomdi* continues to grow in thickness and size and supports increasingly more vegetation of different kinds. Tall reeds and bushes upto three metres tall are observed growing on the *phoomdis*.

The high proportion of vegetable matter in the *phoomdi* gives it a low specific gravity and high buoyancy to keep it afloat. They float on the lake water with about one-fifth of their thickness above and four-fifths under the water surface. About one metre thick *phoomdi* easily supports the weight of animals and human beings— more than 1,500 hutments have been found on the floating *phoomdis* of the lake. Larger *phoomdis* (about 150 sq m area), which are about 2 metres thick, readily support one small hut with 4 to 5 people.

The core of the *phoomdi* is composed of detritus which is black in colour and highly spongy. According to Saratchandra (1977), it is constituted of 36% organic carbon, 2.08% nitrogen, 24.98% other organic matter, and 37.94% other residues including the mineral matter. The ash left after ignition is 36.62% of the total volume.

Phoomdis are the habitat of a large variety of aquatic, semi-aquatic and terrestrial plants (Appendix II C). Among the dominant plants are the several species of grasses and sedges. The reeds (*Phragmites karka*) alone constitute about half the vegetation, particularly in the Keibul Lamjao National Park area.

Phoomdis have been known to be a characteristic feature of Loktak lake and other adjacent *phats* for more than a century. Anandale (1921) referred to the swampy nature of the lake due to the floating mats of vegetation. Similar floating mats are of common occurrence in many other shallow lakes of the world. The *phoomdis* differ from similar floating islands in Dal



A thick mass of *phoomdi* supporting hutments

lake (Srinagar Kashmir) in that the latter were formed by the local people for cultivating vegetables. There is however, not enough information on the major plant species that have contributed to the formation of *phoomdis* in the past. During the late 1920s water hyacinth was introduced in the Loktak area by the former ruler of Manipur despite the fact it had already created severe problems in Bengal and Burma by spreading rapidly and choking the water bodies. Water hyacinth proliferated in Loktak lake and contributed greatly to the formation of *phoomdis*. It became a serious threat to the lake and its fisheries until it was successfully controlled during 1988 - 89 by the introduction of two species of weevil *Neochetina eichhorniae* and *N. bruchi*. However, the area previously occupied by water hyacinth has since been reoccupied by the spontaneous spread of the *phoomdis*.

Until the Loktak lake was converted into a permanent waterbody in 1983, *phoomdis* had a characteristic annual cycle of floating in the rainy season with the rise in water level and settling down on the lake bed during the dry season. Whereas the decomposition of the detritus would be accelerated and the growth of aquatic vegetation retarded during the dry period, the vegetation growing on *phoomdi* used nutrients from the soil. After the rains started filling the lake basin, the *phoomdis* again became afloat due to their bouyancy as well as the gases formed during decomposition. The rising *phoomdis* carried a lot of soil with them from the lake bed through the roots which helped them grow in size and thickness. This annual cycle has now come to a halt and the *phoomdis* remain floating throughout the year except in the shallow shore areas of the lake. The impact of this change on the growth of *phoomdis* is yet to be evaluated.

USE OF WEEVIL SPECIES FOR CONTROL OF WATER HYACINTH

Until recently, water hyacinth (*Eichhornia crassipes*) was the most serious problem in the Loktak lake. Numerous efforts of the government to control this noxious weed by manual removal as well as chemical weedicides remained unsuccessful. Large scale application of weedicides was also not desirable due to the fisheries and the multiple use of the lake water.

However, biological control by releasing the introduced weevil species, *Neochetina eichhorniae* and *Neochetina bruchi*, has yielded excellent results. The weevils were introduced first in 1988 by the then Chief Engineer of Loktak Hydroelectric Project, Mr Nambiar. The weevils, procured from the Indian Institute of Horticultural Research, Bangalore, were released in two phases: 2500 insects on 25 April 1988, and 10,000 insects on 29 August 1988. The two weevil species almost completely cleared all the water hyacinth in the lake within two years and presently no more than 5% of the original proportion remains.

Though the weevils were released without any experimental trials for their efficacy and impact on non-target species in the state, a detailed investigation undertaken later by Tombi Singh (1991c) confirmed that the weevils feed specifically on water hyacinth only. None of the 80 other economically important plant species tested in the study, were used as food by the weevil. The weevils could temporarily feed on some plants such as *Canna indica*, *Pistia stratiotes*, *Musa paradisca*, *Raphanus sativus*, *Brassica nigra*, *B. oleracea*, *Hydrilla* sp., *Trapa natans*, *Amorphophallus* sp., *Monocharia hastata* and *Colocasia* species. However, they could not reproduce on these plants. Therefore, after water hyacinth was controlled, the weevils also disappeared as they could not reproduce further.

Huge amounts of dying and decaying water hyacinth sank to the bottom of the lake contributing to the raising of the lake bed as well as to the eutrophication. Indeed, elevated levels of nutrient concentrations were observed during mid-1989 when the turbidity was also high. Another significant change following the control of water hyacinth has been a rapid increase in the growth of *Salvinia natans* all over the water surface.

Zooplankton

The zooplankton are represented by 55 species (Appendix III A) including Protozoa (16 species), Rotifera (15 species), Cladocera (14 species) and Copepoda (10 species). The dominant taxa are *Difflugia*, *Didinium*, *Vorticella*, *Keratella*, *Brachionus*, *Polyarthra*, *Cyclops*, *Eucyclops* and *Mesocyclops*. The cladocera are most abundant at all places except in the macrophyte dominated areas where the rotifers outnumber the others.

The zooplankton population density varies seasonally from 36 individuals per litre in February/July to 442 in April in the open water area whereas the zooplankton are absent (in February) or fewer (240 individuals/l) in the macrophyte dominated areas. The zooplankton population exhibits a bimodal growth with a peak in late spring and another in autumn. The biomass ranges from 5.1 to 68.0 mg/m^3 in the open water area and 0 to 36.9 mg/m^3 in the macrophyte dominated parts of the lake.

Macrofauna

The macrofauna include a number of vertebrate and invertebrate species inhabiting the water, Keibul Lamjao National Park, *phoomdis*, islands and other habitats. A total of 425 species of animals (249 vertebrates and 176 invertebrates) have been identified from the lake (Appendix III B). The invertebrates include 16 species of annelids, 150 species of arthropods and 10 species of molluscs. The vertebrate fauna include 6 species of amphibia, 106 species of birds and 32 species of mammals (Tombi Singh, 1991 and 1992). The total faunal diversity is likely to be much higher as many species have not been properly identified.

Of these, 34 species (5 mammals, 3 birds, 9 reptiles, 3 amphibians, 12 fishes, 2 molluscs and 1 annelid) which were reported to be abundant in the past have declined and are now disappearing gradually. The fauna include some rare (e.g. the reptile *Python molurus*) and endangered species (e.g. *Muntiacus muntjak* and *Cervus eldi eldi*). At least one species of bird is reported to have completely disappeared. Brow-antlered deer (*Cervus eldi eldi*) is the most seriously endangered species which inhabits the Keibul Lamjao National Park, its only natural habitat in the world.

Avifauna

Loktak lake provides refuge to thousands of birds which belong to at least 116 species (Tombi Singh 1991 & 1992) (Appendix III B). Of these, 21 species of waterfowl are migratory, most migrating from different parts of the northern hemisphere beyond the Himalayas (Table 2). These migratory birds spend their winter (October to March) in and around the lake. In recent years it is believed that the waterfowl population, specially that of the migratory birds has gradually declined. Hume (1988) has recorded 57 species of birds in Loktak lake alone during February. Singh (1971) also states that large numbers of waterfowl including several species of ducks and geese visit Loktak lake although a proper census was not undertaken.

Fishes

The fish fauna of Loktak lake comprises 64 species (Appendix III B). Two of these species *Monopterus albus* and *Osteobrama belangeri* are restricted in their distribution to the Yunan state of China, Myanmar and Manipur only.

Loktak lake serves as the breeding ground for several species of migratory fishes such as *Labeo dero*, *L. angra*, *L. bata*, *Cirrhinus reba* and *Osteobrama belangeri*. These riverine species migrate from the Chindwin Irrawaddy river system in Burma to the upstream areas of Manipur river and breed in various shallow lakes in the valley (Tombi Singh, 1991a and 1993). They grow in the lakes into fingerlings which are known locally as *Thanak* (for *O. belangeri*) or *Ngaton* (for other species).

KEIBUL LAMJAO: HABITAT OF THE *SANGAI*

Keibul Lamjao National Park (24 14'N - 24 26 N 93 53 - 93 60 E) is unique in being the only floating wildlife reserve in the world. It is comparable to the Schwingmoor (quaking bogs) of European peatlands. It occupies the southern part of Loktak lake south of Thanga Ithing and Sendra islands/hills and covers an area of about 40 sq km. It is composed of a continuous mass of floating *phoomdi*. The north eastern border of the park is marked by the open water of the main Loktak lake.



Manipur brow antlered deer or *sangai*



Zizania latifolia, the favourite food plant of *sangai* growing luxuriantly on a cut piece of *phoomdi*

The park is the only natural habitat of the most endangered mammal, the brow antlered deer (*Cervus eldi eldi*) which is represented by about 100 individuals only. Locally known as *sangai*, this sub species of deer was reported to be completely extinct in 1951 but a survey conducted under the auspices of the IUCN discovered a few survivors in 1953 in a small pocket of the floating park. Consequently the Government of India declared about 52 sq km area of Keibul Lamjao as a Wildlife Sanctuary in 1954. The deer population was recorded to be only 14 heads even in 1974. Subsequent conservation measures together with the declaration of the present area of 40 sq km as a National Park in 1977 have yielded satisfying results. The deer population gradually increased to a viable number of 76 in 1986, 82 in 1987, 98 in 1990 and 106 in 1991 (Tombi Singh 1991). However, human encroachment into the park is reported. In the absence of any delineation of the park into core zone, manipulation zone and buffer zone, there is virtually no restriction on humans trespassing into the protected area for fishing, collecting fodder and edible plants and accessing convenient fish landing stations.

Sangai are especially adapted to their characteristic floating habitat. The deer has divided hooves and its pasterns are greatly elongated unlike those of other deer species. Therefore the animal can walk conveniently over the quaking surface.

Table 2. Migratory Birds In Loktak Lake

Species	Common Names	Species	Common Names
Anas clypeata Linn	shoveller (M)	*A nyroca* Gulden staedt	ferruginous duck (M)
A strepera strepera Linn	gadwall (M)	*Netta rufina* Pallas	red crested pochard (M)
A crecca crecca Linn	common teal (M)	*Dendrocygna javanica* Horsfield	lesser whistling teal (LM)
A penelope Linn	wigeon (M)	*D bicolor* V	large whistling teal (LM)
A acuta Linn	pintail (M)	*Fulica atra atra* Linn	coot (M)
A querquedula Linn	garganey (M)	*Grus monacha* Temminck	hooded crane (M)
Tadorna ferruginea Pallas	brahminy duck (M)	*G antigone* sharpii S	sarus crane (LM)
Tadorna tadorna Linn	common shelduck (M)	*Psittacula eupatria* Linn	alexandrineparakeet (LM)
Anser anser rubrirostris	greylag goose (M)	*P cyanocephala* Linn	blossom headed parakeet (LM)
A indicus Latham	bar-headed goose (M)		
Aythya ferina Linn	pochard (M)		

Source Tombi Singh 1991 & 1992

M - Migratory

LM Local Migratory

The fingerlings start their downstream migration with the onset of the monsoon Some of the fishes start migrating to the rivers later during the winters (November December) These fishes grow slightly larger in size and are locally known as *Ngaton tolaba* They attain sexual maturity in the larger river system and are known as *pengba* (*O belangeri*) or *khabak* (other species) Because the adult fishes migrate in huge shoals of several thousands in a group, they constitute a major seasonal fishery of the lake commonly known as *pengba* and *tharak* fishery (*O Belangeri*) and *ngaton* and *kabak tharak* fishery (other species) In the past they accounted for about 40% of the natural fishery resources of the Manipur state However these fishes have disappeared from the lake since the construction of Ithai barrage which has blocked their migratory route



R K SHYAMANANDA SINGH

Fisherwoman lifting a Chinese dip net while manouvering the canoe in the eastern lake basin

Ecosystem Processes

The ecosystem processes in the Loktak lake have not yet been properly investigated There is no information whatsoever on the rates of production by phytoplankton and different macrophytes, the nutrient uptake and decomposition of aquatic vegetation the production and role of zooplankton and benthos in fish production or of the avifauna The impact of the permanent water on major flora and fauna has also not been systematically investigated and needs to be taken up urgently

Functions And Values Of Loktak Lake

oktak lake has been considered to be the life-line for the people of Manipur due to its importance in their socio-economic and cultural life besides influencing the climate of the state. The socio-economic values of the lake include hydropower generation (Loktak Hydel National Project), irrigation of 24,000 ha of agricultural land, fisheries, control of floods, supply of drinking water, production of aquatic organisms of food and commercial importance, the many uses of *phoomdi* and water transport. Among natural values the most important is the conservation of wildlife including many rare fishes and migratory birds, besides the maintenance of high biodiversity.

Economically Important Biotic Resources

Loktak lake produces a large number of aquatic plants and animals useful as food and (or) prized for their commercial value although there has been no systematic programme of aquaculture. About 22 plant species and 12 animal species are used as food and are commercially exploited (Appendix IV). Prominent among the food plants are *Trapa natans bispinosa*, *Euryale ferox*, *Zizania latifolia*, *Alpinia* sp., *A. allughas*, *Ipomoea* sp., *Nymphaea alba*, *N. stellata*, *N. lotus* and *Nelumbo nucifera*. The predominant species among the aquatic vegetation of commercial importance are *Phragmites karka* and *Erianthus* which are extensively used for roofing and wall fencing of houses. *Leersia hexandra* and *Sacciolepis myosuroides* are extensively used as fodder for cattle. Once found in abundance, all these wild plant species served as the main source of income for the local people. During recent years the production has been greatly reduced due to excessive exploitation.

The *phoomdis*, which constitute a very prominent characteristic feature of the Loktak, serve the local populace in several ways. A unique feature associated with the *phoomdis* is the presence of numerous (around 1500) hutments. These huts have been serving as temporary camps for the fishermen during the fishing season. Prior to the commissioning of the Loktak hydroelectric project, which resulted in the conversion of Loktak into a permanent reservoir, these hutments were temporary dwellings which could be easily moved from one place to another in response to changes in water level during the rainy season. Since the construction of the barrage, however, these huts have been converted into permanent settlements on the floating *phoomdis*. Kitchen gardens have developed around the homesteads and a number of domestic fowl and duck are also seen.

A 1.5 m - 2 m thick *phoomdi* mass, measuring 15 m x 15 m can support a single hut. The huts (normally 2-4 m wide and 4 m - 5.6 m long) are made of light material like bamboo, wood planks or reed (*Phragmites karka*). The floor is made up of wooden planks or bamboo and made thicker (2 m - 3 m) by adding several layers of *phoomdis*. Bamboo or wooden pillars are erected pushing down the *phoomdis* through the floor to make a frame for the hut. The hut is thatched with straw or weeds such as *Zizania*, *Imperata cylindrica* and *Erianthus* sp. which are commonly found growing on the *phoomdi* itself. The wall of the hut is covered with reed (*Phragmites karka*) or pieces of bamboo which sometimes is plastered with straw and clay.

The huts are usually anchored at a convenient place for fishing with the help of bamboo poles on all sides to avoid its displacement by wind. However, this is a



Floating hutments on the Lake

temporary arrangement and whenever another suitable site is located the *phoomdi* is pushed as a raft using bamboo poles and fixed at another selected site. The increasing number of these huts has, however, become a problem for the management of the lake. The population of people dwelling on these hutments is estimated to be around 3000. The domestic sewage and waste from floating hutments which is directly discharged into the lake is accelerating the process of eutrophication. Further the use of chemicals such as DDT to fight the mosquito menace has added to the problem of pollution.

Phoomdis are also of immense value to the local population in fishing for which they have traditionally been utilised.

FISHERIES

The fishery in Loktak lake has traditionally been open water capture fishery which before the introduction of modern pisciculture in Manipur state in the 1950s accounted for 60% of the total fish production of the state. Migratory fishes from the Chindwin - Irrawaddy system of Burma (Myanmar) used to contribute about 40% of the capture fishery of the lake. The commissioning of the Loktak hydroelectric project however brought about changes in the fish and fisheries of Loktak. Migratory fishes have, since then disappeared (Tombi Singh 1993) while the state fishery department has been trying to compensate the loss by introducing millions of fingerlings of Indian and exotic major carps


A congested settlement facing the government - owned Takmu fish culture farm, a 500 ha enclosure separated from the main waters of Loktak

Long before plans for the Loktak Hydroelectric Project were made in the 1970s, an area of 500 ha in the Takmu sub-basin was taken over by the state government for intensive fish culture. At present, apart from the Takmu beel fishery, the lake is open to the public for natural capture fishery without the requirement of any lease or licence.

More than 100 000 people on and around the lake depend for their livelihood to a great extent on the lake fishery, which is now a mixture of capture and culture systems. The lake yields about 1 500 tonnes of fish per year.

Pisciculture is practiced in the peripheral areas of the lake, particularly along the inhabited islands such as Thanga and Karang, where fish ponds (20 - 30 m wide and 30 - 50 m long) have been constructed by local fishing communities. About 150 such semi permanent ponds exist along the settled islands of Loktak. *Phoomdis* are used extensively for making the boundary walls of these ponds. *Phoomdi* strips 2 - 3 m wide are cut and deposited on the boundary separating the pond from the lake. Earth collected from the hillocks is then placed above the *phoomdi* so that the latter sink down. More layers of *phoomdi* and soil are deposited till the boundary is raised by about 1 m above water level. The nutrients leaching out from the decomposing *phoomdis* could probably serve as manure in such ponds. Several kinds of fish including the major Indian and exotic carps are cultured in these ponds. Some fishermen even avail loans and subsidies from agencies such as Council for Advancement of People's Action and Rural Technology (CAPART) and National Association of Fishermen.

Despite the growing popularity of pisciculture, capture fishery still prevails and the native fisherfolk continue their traditional practice of *phoom* - fishing and other specialised indigenous techniques, some of which are quite interesting.

Irrigation

Since time immemorial Loktak lake has been used for irrigation of the surrounding agricultural fields. With the commissioning of the Loktak Hydel National Project in 1983, lift irrigation facilities are provided for 24 000 ha of agricultural land. The multipurpose Loktak Lift Irrigation Project of the Government of India consists of installation of seven pumping sets for lifting 600 cusecs of water at the first stage. There are two more pumping houses for the second stage of a 100 km long lift canal network. The ultimate annual irrigation benefit will reach 40 000 ha of agricultural land.

Energy Production

Presently, Loktak lake is the only source of water for hydropower generation in the state. The multipurpose Loktak Hydro Electric National Project, commissioned in 1983, has diverted the flow of Manipur river into the lake by constructing the 10.7 m high Ithai barrage and lifting 58.8 cusecs of lake water for power generation and irrigation. It has an installed capacity of 105 MW power of which only 35 MW are used within the state and the rest sold to the neighbouring states.

Recreation and Tourism

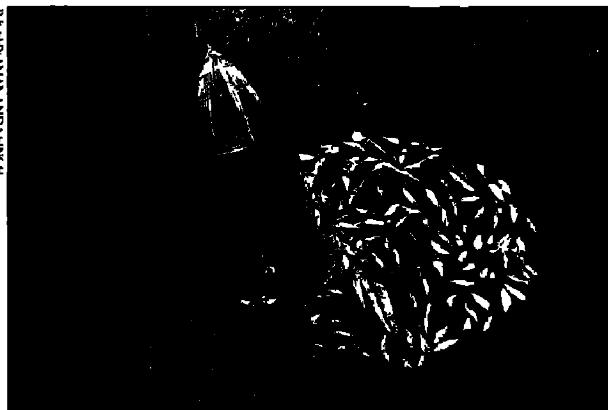
Loktak lake is the most important tourist spot of Manipur. It serves as a beautiful spot for recreation and water sports, attracting a large number of tourists. The beautiful islands inside the lake, vast areas of open water as well as those covered with colourful flowering water lilies and lotus, together with the rich biota (especially orchids in the surroundings) provide a special ambience attracting tourists. The enchanting scenic beauty of Loktak lake - the biggest freshwater lake in northeastern India— lies in its tiny islands and lush green fringes, boat routes amidst floating marshes

TRADITIONAL FISHING METHODS IN LOKTAK LAKE

The native fisherfolk of Loktak still continue to use the traditional fishing gears and fishing methods. Both individual and organized fishing are practiced. Primitive canoes made up from a single log of tree such *Artocarpus chaplasa*, *Cedrella tuna* and *Phoebe* spp. are still in use. These logs help in navigating through dense growth of *phoomdi* where broad plank built boats fail to operate. The main fishing gears include hooks and gorges, dip nets, lift nets, cast nets, nets (scooping and skimming), gill nets, drive-in nets, several kinds of traps locally known as *kabo-loo*, *tauthum*, *sora-loo*, *tekhao loo*, *loo kak*, *taijep*, and plunging baskets. Very little modernization has taken place in the traditional fishing crafts, gears and fishing techniques.

A month after the first phase, the second phase of *phoom* fishing called *Phoom namba* is carried out. This phase involves a team of some 20 fishermen and women on 5-6 canoes working from dawn to dusk. First, the circular *phoom* is surrounded with tarpaulin touching the lake bed leaving no room for the fishes to escape. Then the floating plants from the middle of the circle are gradually removed to clear space for the fishermen to move in with their fishing crafts and gears. The bottom sediments are disturbed with the bamboo poles and the churning motion of the canoes. The high suspended silt and organic matter load soon deoxygenates the water. This results in mud clogging in the gills of the trapped fishes which soon start surfacing due to want of oxygen. The women haul the disturbed fishes with their dip nets. A single operation may yield upto a

A newly set ring of *phoom* being filled with vegetation for *phoomdi* fishing



Traditional fishing gear including cages and drying tray

Phoom fishing, which is still extensively practised in Loktak lake, is a two phase operation. In the first phase called *phoom tolba* large circular *phooms* (2.5 m wide and 1 m thick) are prepared and kept floating in the shallower parts of the lake. This is done during the early part of the winter season when the wind and water is calm. During winter the lake is covered with several such circular *phoom* patches. Fishes assemble beneath these *phooms* possibly due to higher temperature and greater availability of food.

ton of fish a day. *Phoom* fishing is a typically shallow water fishing technique. Now that the water level in the lake remains permanently high as a result of the Loktak hydel project the churning effect cannot be readily obtained because of the increased lake depth. This had compelled fishermen to use pesticide formulations to madden the fishes during *phoom* fishing for some years. Recently however this practice has been stopped due to the efforts of the government and various voluntary organizations.

varied coloured water plants, fishing nets dancing in the sparkling mass of water, innumerable circles of *phooms* encircling the clear water, the unique fishing methods and exotic migratory birds.

The National Park on the floating *phoomdis* of Keibul Lamjao, hosting the most seriously endangered species of brow-antlered deer is another major tourist attraction.

TRANSPORT

Though the lake is shallow and dominated with dense growth of macrophytes which do not permit the movement of large boats and launches, the local fishermen conveniently use the dug out canoes for fishing and transporting fish catch, paddy, reeds for thatching, fodder, etc. across the lake.

GROUNDWATER RECHARGE

Many wetlands have an important function of recharging the ground water. In the Manipur valley the groundwater table is very high (2 m - 4 m below surface). Because the valley has a very small N - S gradient with a slope of only about 25 m, it is quite likely that Loktak lake is fed by groundwater discharge from the western piedmont area and northern higher slopes and at the same time contributes to the recharge of groundwater towards the southern end of the valley. Specific studies have, however, yet to be undertaken.

FLOOD MODERATION

The Manipur river which drains the whole Imphal valley is the lone outlet of 52 lakh hectare metre annual yield of surface runoff from a catchment area of



Dug-out fishing canoes made from single logs

6332 sq km. The river has been unable to carry the large volume of water generated in peak flows during the monsoon season, and its capacity has been affected also by the downstream natural barrier called the Sugnu hump. Therefore, the Loktak lake and other shallow lakes on the either side of the river served as moderators of flood by accommodating the spillage. The lake area fluctuates from 55 sq km in the dry season to over 300 sq km in the rainy season.

However, since the construction of Ithai barrage, the lake has been converted into a man made reservoir with the water level maintained at 768.5 m. The time and volume of discharge of the Manipur river downstream of Ithai barrage are determined by the water level in the Loktak lake. This has resulted in severe flooding events in other parts of the valley during the last decade.

Water Quality Regulation

Wetlands are known to be efficient regulators of water quality. Luxuriant growth of macrophytes, especially free floating and emergent forms, contribute significantly to nutrient stripping from eutrophic waters, and thus help in improving the water quality. But in Loktak lake the nutrient loading, from both external and internal sources, far exceeds the assimilative capacity of the macrophytes. Since Loktak lake has become a closed system with no outlet, the nutrients remain within the system and their concentration continues to increase. This has resulted in phytoplankton blooms as well, in open water areas.

In spite of the fact that *phoomis* trap incoming silt effectively, siltation of the lake has been accelerated due to increased inflow of the silt laden waters and the total stoppage of its loss with the outflow due to the Ithai barrage.



Changing Ecological Character Of Loktak Lake

Currently, Loktak lake is threatened by excessive loading of silt and nutrients from various anthropogenic sources. Deforestation and shifting cultivation, uncontrolled use of fertilizers in the agricultural lands, discharge of domestic wastes and sewage from the human settlements including those on *phumdis*, all contribute to input of silt, nutrients and biogenic salts into the lake. This will accelerate the ageing of the lake by rapid siltation and excessive biomass production. A major change in the ecological character of the lake has been its conversion to a reservoir by the construction of the Ithai barrage for hydel power generation.

Loktak Multipurpose Project Environmental Impact

The multipurpose Loktak Hydro Electric National Project was initiated by the Ministry of Irrigation and Power, Government of India in 1971. The project was executed by the National Hydro Electric Power Corporation and commissioned in 1983. It has an installed capacity to generate 105 MW of power by 3 units of 35 MW each and to provide lift irrigation for 24,000 hectares of land.

The project involved the construction of the Ithai barrage downstream of the confluence of Manipur river and Khuga river and diversion of water from the Loktak lake (768 m above MSL) to the power house situated in the Leimatak valley (454 m above MSL) through an open channel. The Ithai barrage (10.7 m



Logging operations along a feeder stream of Loktak Lake

high, with 5 m x 10 m span water ways) creates an impoundment and backflow of water into the Loktak lake through the Khordak cut. About 58.8 cusecs of water, of which 42 cusecs are used for power generation and 16.8 cusecs for irrigation, are diverted from the Loktak lake. The project brings to the state an income of 20 to 30 crores annually from the sale of electricity to the neighbouring states (Nagaland, Assam and Tripura).

The lift irrigation component consists of seven pump sets for pumping 600 cusecs of water from the open channel at Ningthoukhong. Another two pump houses are in Bishenpur for the second stage lifting. A 100 km long network of canals distributes the water to the fields.

Like other mega projects, Loktak Multipurpose Project also had both benefits and adverse impacts. The lift

LOKTAK MULTIPURPOSE PROJECT

Costs

- Inundation of cultivable land and habitation (50,000 - 80 000 ha)
- Uprooting of local communities from their traditional sources of livelihood creating unemployment and deterioration in the socio-economic conditions
- Disappearance of over 20 species of aquatic plants of economic and commercial importance
- Excessive accumulation of *phoomdis* and conversion of floating hutments on them into permanant dwellings increasing the domestic wastes draining into the lake and accelerating eutrophication
- Disappearance of the indigenous species of fishes that would migrate from the Chindwin river to the Imphal river
- Declining waterfowl populations
- Thinning of *phoomdis* deteriorating the habitat of the Manipur brow-antlered deer

Benefits

- Generation of 105 MW of power to an otherwise energy starved state
- Provision of irrigation to 24,000 hectares of land
- Generation of an income of 120 - 30 crores annually for Manipur State from the sale of electricity to neighbouring states of Nagaland, Assam and Tripura
- Enhanced potential for economic development - tourism, industry, agriculture, and aquaculture


VIBODH PARATHASARATHI

Loktak hydroelectric power plant

irrigation has not been very successful while the electricity generated has catered to the requirements of the otherwise energy-starved hilly state and some of its neighbours. While the project authorities claim to have brought 'a new era of development' to the people of the region, counterclaims by a large population of the project affected areas stress that the project has doomed the economic life of a large section of southern Manipur valley and severely altered the ecology of the lake.

The project has caused both gains and losses in different aspects of the lake environs. Before the commencement of the project the shallow macrophyte-dominated lake, was getting rapidly converted into a sedge meadow. But for the permanent impoundment of water in this lake by the project the lake could have been reclaimed for a variety of activities like agriculture, fishery, settlement, cattle grazing, etc. Now the growth of amphibious and terrestrial vegetation has been retarded by the permanently high water level. Therefore the project has, in fact, effected rejuvenation of the senile lake.

However the public grievances and other environmental side effects are quite significant. These have been caused primarily by three factors namely the inadequate investigation and lack of environmental concern at the time of project formulation, improper management of the project at present and the project authority's apathetic attitude towards public grievances caused by the project.

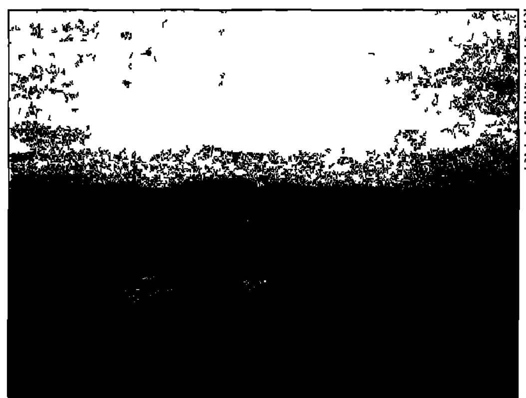
The salient impacts of the project are as follows:

- The impoundment of water by the Ithai barrage has inundated 80,000 ha of agricultural land besides some settlements in the southern Manipur valley.
- The population of resident and migratory waterfowl, several fishes and macrophytes have sharply declined.
- The permanent water has caused thinning of the *phoomdi* in the Keibul Lamjao area, the habitat of *sangai*. This has resulted in the stunted growth of the shelter and food plants, thereby threatening the life of the deer.
- The siltation in the lake has been accelerated as the outflow of the silt-laden waters has been checked.
- The efficiency of the natural vegetation mats and water hyacinth to strip nutrients from the water has declined because all the undecomposed organic matter keeps on accummulating in the lake.

All these impacts have not been systematically investigated so far and a proper Environmental Impact Assessment (EIA) has not been conducted.

SILTATION

The most important cause of soil loss from the catchment area is the shifting cultivation. The land slides and construction of roads in the hilly catchment



Erosion along the hill slopes of Thanga island due to quarrying for fish ponds and the construction of a motorable road

also contribute to soil loss. It is estimated that about 50% (3,36,325 tonnes) of the total soil loss from the catchment are deposited in the lake every year (WAPCOS 1988).

Another unknown but equally significant amount of sediment load is contributed by autochthonous factors like undecomposed organic matter. The Ithai barrage has also resulted in accelerated rate of siltation. This is demonstrated by the fact that within a decade the Khordak channel was completely choked with silt and dredgers had to be deployed to remodel the channel. The southern part of the lake just above the barrage now has sandy beds in place of the earlier fibrous peat.

Eutrophication

Loktak lake suffers from both natural and cultural eutrophication. The infestation by aquatic and semi terrestrial vegetation had already been more than a century ago as it is recorded in the literature (Anandale 1921). Apparently until recently deterioration in the ecological health of the lake occurred subtly and steadily. Further complications must have been added due to variations in water level, human pressure on land and increased efficiency in landscape modification. Now the lake basin receives 137.74 tonnes of P and 1152.14 tonnes of N per sq km per year from its catchment (Shyamnanda 1991). The rate of fertiliser application in the surrounding fields with high yielding varieties of paddy is estimated between 100 and 200 kg/ha. Surface runoff from some of these fertilised paddy fields were found to contain 85-900 µg/l of P and 200-1150 µg/l of N. Therefore eutrophication seems to have been more rapid in recent years. At present Loktak lake is heavily eutrophic and under a delicate balance of phytoplankton macrophyte competition and is always ready to tilt in any direction— of either rapid water quality deterioration or rapid shallowing due to unchecked biomass accumulation.

High concentrations of total P (152 mg/m^3), total N (657 mg/m^3), chlorides (55.7 mg/m^3), and maximum chlorophyll content (130.6 mg/m^3) as well as the Secchi disc transparency (1.61 m) indicate the eutrophic nature of the Loktak lake.

Soils in the catchment are rich in phosphorous (16-21.5 ppm) and nitrogen (63 ppm of NO-N and 50 ppm of NH-N) (Tombi Singh and Shyamananda 1988). These values suggest the possibility of a high nutrient loading into the lake due to soil erosion in the catchment. The total annual external loading of P and N into the lake has been estimated on the basis of standard factors and the area of catchment under different landuse. The surrounding agricultural areas of the catchment contribute most of the phosphorus and a major share of nitrogen load in the lake (Table 3). This is confirmed by the analysis of the agricultural run-off from the western side of the lake. During July 1987 the runoff had 200-1150 µg/l of total nitrogen and 85-900 µg/l of total P.

Table 3 Annual external nutrient loading of Loktak lake

	Watershed Landuse	(Tonnes y^{-1})	
		Total P	Total N
1	Urban	2.94	14.7
2	Rural and Agriculture	127.45	396.9
3	Forest	1.57	47.04
4	Rainfall and Dry Fall out	5.78	693.504
5	Total	137.74	1152.144

Source (*Shyamananda 1991*)

Pollution

Besides the nutrients brought from the catchment with the runoff, additional nutrients enter the lake with the domestic sewage from Imphal carried by the Nambul river. Though there is only negligible inflow of industrial effluents, the organochlorine pesticides from



Series of fish culture ponds along the water front. Expanding pisciculture operations will add to the nutrient loading of the lake

the surrounding paddy fields are another major source of pollution in the lake threatening the biota with their residual effects. Local fishermen have been known to sometimes use pesticides in traditional fishing. So far tourism has not been a major concern largely due to its location and certain restrictions on tourists. Further the tourist facilities in the lake comprise only two small tourist lodges at Phubala (on the west shore of the lake) and on Sendra island. Thus tourism does not contribute significantly to the pollution of the lake but is likely to become another factor in lake deterioration if the plan proposed by WAPCOS (1993) is implemented.

Direct Threats To Wildlife

Both migratory and resident waterfowl populations have dwindled drastically during the past few decades. Hume (1883) who recorded 57 species of waterfowl, stated *"I have not seen any other place in India where such enormous swarms of ducks and geese could be observed on the water as was at Loktak lake and wading birds were almost as abundant in the surrounding swamps".* Though there have been no systematic investigations, shooting and netting, pesticides and hydrological changes as well as increased human presence (fishing, removal of vegetation, recreation, tourism, construction of motorable causeways across the lake, agriculture, etc.) have all been important factors in their decline. The number of floating hutments in the lake has increased from less than 100 to about 1500. Moreover, there has been an increasing tendency among the people to kill the birds and water fowl for consumption and sale. Earlier, birds were trapped when they visited the lake in flocks. In recent years villagers have started killing the birds by poisoning them with toxic insecticides and pesticides which are placed in the small weed fishes or trash fishes used as bait. Hundreds of birds are killed every day for

consumption. Some farmers spread rice grain soaked in Dieldrin or DDT near their fields where paddy is being sown to detract the birds from feeding on their paddy seed. Such methods of killing the birds by using toxic substances are now being gradually discarded. Although there are no records on the avifauna of the Loktak lake to clearly indicate which species have already disappeared, observations of Tombi Singh and Shyamananda and information from other sources show that the following species have disappeared during the past two years.

Scientific Name	Common Name	Local Name
Aix galericulata (Linn.)	Mandarin duck	
Anas querquedula (Linn.)	blue winged teal	*surit angouba*
Anser anser rubrirostris Swinhoe	eastern greylag goose	*lam kanguya*
Anser indicus	barheaded goose	-do
Threskiornis aethiopica melanocephla (Latham)	white ibis	*mayang Urok*

Likewise, the population of many species of endemic fishes has rapidly declined, and the migratory fishes have totally disappeared.

The habitat of the brow-antlered deer is also threatened. Though the wildlife managers have been able to increase its population from 14 to about 100, it faces another threat because the vegetation on the floating *phoomdis* is gradually declining due to the permanent water in the area since 1983. Before the Loktak National Hydel Project, water in the lake exhibited large seasonal changes, and correspondingly the *phoomdis* periodically settled on the exposed lake bed during the dry season. Thus, whereas during the dry period the nutrients were taken by the *phoomdi* vegetation from the bottom of the sediments, much of the mineral and organic matter became part of the floating *phoomdis* as the roots of various reeds and other grasses brought them up after the lake was flooded. Now that the *phoomdis* remain floating throughout the year, mineral matter gradually settles down to the bottom, and the nutrients are no longer procured seasonally from the bottom soil. Therefore, the growth of vegetation on *phoomdis*, particularly in the National Park is getting reduced, and the *phoomdi* layers are gradually decreasing in their thickness. It is feared that the *phoomdi* may not be able to support the weight of the animals. Of course, in certain areas of the park the lake bottom has risen due to siltation, upto the base of the *phoomdi*. The floating *phoomdis* are susceptible to wind and wave action at high water levels, and get broken into smaller blocks which drift into different parts of the lake away from the park. During 1990, about 30 wild boars and one *sangai* were killed by the people when these animals were carried away with a block of *phoomdi* which drift by the wind. Continuous floating of the National Park has made it difficult or impossible to practice occasional controlled burning of the dry vegetation which could enrich the growth of sprouts of certain food plants of *sangai*.

The 40 sq km area of the present Keibul Lamjao Wild Life National Park in Loktak lake has been the main source of income for the people in the surrounding villages of the park since time immemorial. The various human activities in the National Park include fishing, collection of food and vegetables, fodder, weeds and reeds of economic importance, grazing cattle and poaching of wild animals.

A major threat to the park is the growing encroachment on land by the villagers for agriculture and settlement. A vast area inside the park has already been reclaimed illegally.

During June - July 1979, a mob of agitated villagers (about 600 people) reportedly raised objections against



The tree covered strip of land is Khordak village with about 100 houses indenting into Keibul Lamjao National Park

reserving the 40 sq km area of the National Park for a few heads of *sangai*. They attacked the park and burnt down about two-thirds of the park area damaging several check posts, buildings and watch towers besides beating the forest staff. There are areas like Khordak, Laphupat, Sagram and Chingmei inside the National Park with human habitation. For example, Khordak village alone includes about 50 homesteads (families). Their increasing demand on the natural resources and craving for reduction in the park size are a perpetual threat to the park and the survival of *sangai*.



Management Of The Loktak Ecosystem

Present Management Schemes
A Critique

Soon after the commissioning of the Loktak Hydel Project in 1983, the North Eastern Council (NEC), a regional planning and development authority of the north eastern states of India, became worried about the lifespan of the Loktak lake which was now used as a reservoir of the project. It sponsored a workshop of a multidisciplinary team of about 25 scientists from many parts of the country at Imphal in March 1985 to develop a workable strategy for scientific management of the lake. The workshop could not arrive at a concrete management plan in the absence of baseline data about the lake and recommended that a programme of research from diverse angles was essential.

A serious flood in October 1986 came as a severe blow for the 15 legislative assembly constituencies that had been directly affected by the Loktak Project. After a spot investigation with government executives and engineers, a committee was formed to find ways and means to mitigate recurrent (or permanent) floods in southern Manipur valley. Consequently, in 1987, the Loktak Development Authority (LDA) was established with its aims and objectives enshrined in its Memorandum of Association as 'to check the fast deteriorating condition of Loktak lake and to bring about the improvement of the lake along with development in the field of fisheries, agriculture, tourism and afforestation in consultation with the concerned departments of the State Government'. As is evident, while the spirit of the authority was to rehabilitate the deteriorated ecosystem of the lake, it was not clear to them as to how to identify the real ecosystem ailment and necessary scientific treatment thereof.

This fact became clearer when the task of formulating a management design was entrusted with the Water and Power Consultancy Services (India) Ltd. (WAPCOS), a Delhi based Government of India's consultancy organization. WAPCOS compiled a problem identification report within seven months of the contract assignment in 1987 without any research endeavour. Expectedly, the report starkly reflected their total ignorance of the concept, principle and practice of the science of lake ecosystem management which today is a well developed discipline. Local freshwater ecologists pointed out the conceptual deviations of the project contemplated by the LDA and pleaded for a systematic organized research into certain aspects of the ecology of the lake. But unheeded by this move, the authorities went ahead and awarded another contract to the WAPCOS for formulating a detailed master plan.

The master plan submitted recently (WAPCOS 199[illegible]) after several revisions has turned out to be an economic development project with its major thrust on development of fisheries, tourism, agriculture etc. The planned development activities include the construction of a 126 km long dyke encircling the lake, dredging of a major portion of the lake bottom, a large number of sluice gates, culverts, bridges and canals etc. All activities are directed by a mechanical approach. For the lake managers, siltation appears as the only cause of ecological problems. The corrective measures have not taken into account the problem of eutrophication which is a physiological ailment of the lake. This cannot be cured or managed without understanding the ecosystem dynamics of the lake which the authorities have failed to realize as relevant in their programme. The master plan has not considered the causes and remedies of the

rapid decline in the wildlife particularly the avifauna and the problems of the famous brow - antlered deer. On the contrary, many schemes have been designed to alter the natural landscape of the lake such as the destruction of many hillocks which form picturesque islets in the lake, encouragement of settlements inside the lake, establishment of large pen culture farms midwater, dumping of large quantities of floating *phoom*s and the encircling of the lake by an artificial dyke with boulder rib-rabbing along the shoreline. All these activities will lead to gross physical modification of the lake, mutilating the natural landscape, impairing the ecological balance and accelerating the eutrophication and water quality deterioration.

Many of the contemplated development activities are unrealistic in terms of their feasibility, compatibility, cost justification etc. The WAPCOS and for that matter the LDA while aiming at the enhancement of economic utility of the lake and its romantic beautification have ignored the problems of ecological health of the lake. Its implications are that the lake is very likely to be converted into an ecological slum by a defective management programme thereby frustrating the very spirit of saving the sick lake.

Management of Keibul Lamjao National Park

The protection and management of the Keibul Lamjao National Park are under the charge of the wildlife division of the State Forest Department. Coordination between the forest department and the lake management authority is unsatisfactory if not completely lacking. The management steps being identified by the LDA for improvement of the park have not been clearly specified and therefore very inadequate. Among the measures suggested are a ban on cultivation in the park area, preventing entry of people by effective barrication, siltation control, education and public awareness.

Sustainable Utilization of Lake Resources: Some Perspectives

Resource Identification

The present conflicting uses and hence the conflicting management priorities are the result of differences in perception about what kind of a resource the lake is. A large population would like to see the lake filled so that it can be converted into productive rice fields. Another group prefers a shallow lake than a deep lake for traditional fishing methods are more conveniently practiced in shallow waters. Yet a third group, the engineers, regard the lake as a large tank for storage of sufficient water to meet the requirement of the hydel project and seem to be little concerned about the rich biodiversity and wildlife that the lake supports.

What the management authorities need to realize is that eco-development holds answers for all questions of sustainable resource tapping. Therefore, first of all, the lake should be identified as an ecological resource.

Problem Identification

The prospects of all economic activities based on the lake's resources will be marred with the ecological deterioration of the lake. Therefore, the deteriorating ecosystem should take the first priority in any plan of lake management. For Loktak lake the following problems demand the immediate attention of the lake managers:

- ecological problems viz. natural ageing, siltation, cultural eutrophication, pollution and changes in biotic resources and wildlife
- encroachment and reclamation
- reduced water storage in the lake basin

- submergence of 80 000 ha of agricultural lands and enhanced flooding events due to the Loktak Multipurpose Project

Other tasks like the development of foreshore, road communication, tourism and fisheries which presently are a priority in LDA plan are secondary and should be subjected to analysis of their ecological compatibility

Concept of Lake Management

Development of a deteriorated ecosystem is either a misnomer or a misconception An ecosystem cannot be developed but it can only be managed Management involves sensible resource tapping and components of ecosystem rehabilitation The lack of conceptual clarity has transformed the Loktak Development Authority primarily meant for lake conservation, into an eco nomic development agency with its distorted aims and objectives

Ecosystem Management

It is an established convention that the natural ecosystems should be managed with the least possible alteration of the existing biotic and abiotic components The construction of the artificial shoreline with associated structures like canals bridges causeways, culverts sluice gates, check dams, etc , as contemplated in the LDA plan should be reconsidered as all these activities will cause a gross physical modification of the natural landscape and alter the biogeocoenosis of the lake system Adequate studies should be undertaken on the possible alternatives that may help achieve the desired results without destroying, or with reduced disturbance to, the existing features of the lake (except removal of undesirable elements like excessive vegetation)

Conventional Practice

Conventional practices of lake management resort to containing the problems of siltation and eutrophication The LDA plan does not envisage any measure to manage eutrophication As a measure against siltation desilting of the lake by dredging has been emphasized But, deepening of the 289 sq km big lake even by one metre sounds a utopian dream No such attempt has been made in any lake of similar size in the world Piecemeal dredging may be considered for Loktak lake when demanded by specific situations Whole lake dredging has been successful in the case of lake Trummen and lake Trehorningen in Sweden But these are just 1 sq km and 0 5 sq km respectively in area

Lake dyking too is considered as a forbidden practice in lake management science as it causes many undesirable effects like unmanageable hydrological anomalies shrinkage in lake area, changes in the shoreline configuration and the nutrient regimes, and subsequent water quality deterioration Lake Okeechobee in Florida (USA) is a clear example of the fallouts of lake dyking

The artificial dyke proposed in the LDA plan will provide no solution to the problem of peripheral agricultural lands from submergence by lake water The idea of providing a well defined shoreline to the lake by a dyke and use of the dyke as a road are irrelevant as there is no essential need of embankment of a natural lake and the proposed foreshore road will not improve road communication in the area

Holistic Management

Loktak is one of the many shallow lakes in southern Manipur valley The sizes of other important lakes Pumlen Lamjao Kharung Ikop, Waithou, Loushi Utra, and Sana range between 2 sq km and 30 sq km Besides numerous other smaller lakes and wetlands

are situated in the neighbourhood of these lakes. All these lake and wetland basins are similarly threatened and have a close-knit hydrological and ecological relationship with Loktak lake. Therefore, the treatment of Loktak lake in isolation being planned by LDA will not fetch any tangible result. At the same time their scientific management cannot be postponed till the completion of management of Loktak lake because after, say 20 years of experience in Loktak when the State government begins to pay attention to other lakes, they would have already vanished.

Therefore, it is high time for the State government to take up the management of Loktak lake in a comprehensive holistic manner by incorporating other neighbouring lakes in the master plan. This will not only save the smaller lakes from extinction but facilitate greater progress in the management of Loktak lake.

The compartmentalised treatment of the lake such as the maintenance of a particular water level (768.5 m above MSL) in the lake enclosed by a raised watertight earthen dyke will never help in correcting the hydrological anomaly and flood situations in the southern Manipur valley. Preservation of water inside the lake modelled to be a large cistern in order to avoid inundation of the peripheral agricultural lands is an absurd proposal. The scheme is not feasible. At the same time the agricultural lands and settlement areas just outside the dyke supposed to be protected by it from lake water will be inundated by impoundment of overland flow from the remaining basin due to the presence of the dyke itself. This might lead to a more serious flood situation. Again, if the scheme is at all successful it will save 20,000 ha in the immediate periphery of Loktak without providing a solution to the problem of inundation in the remaining 60,000 ha around the neighbouring lakes.

Therefore, the dyke-scheme should be abandoned and instead attention should be given to the hydrological management of the lake associated with a comprehensive flood management programme of the southern Manipur valley taking into account the intricate drainage patterns, land relief and climate of the area.

Dredging is meaningless if there is no adequate arrangement for the disposal of dredge spoils. Again, dredging with an aim to deepen the whole lake or even a major portion of the 289 sq km lake will be a futile exercise because of the unmanageable dimensions of the work and cost. Therefore, while selective dredging at certain points is justifiable, large scale dredging in Loktak lake is not recommended at least for the time being. Instead, enhancing the storage capacity of the lake by removing 70% of the 206 sq km of *phoomdi* cover on the lake must be given priority. The *phoomdis* are on average 2 m thick and therefore the volume of water displaced by them is quite significant. Permanent removal of *phoomdi* outside the lake involves a fairly big disposal problem. This can be achieved through:

- floating them down the Manipur river during 100 days in the monsoon season when the gates of the Ithai barrage remain open
- supplying cut *phooms* to the public for field manuring or landfill on 'no loss no gain' basis
- milling and chemical processing of the nutrient rich *phoomdi* in specially designed plants for distribution to cultivators as fertilizer in priced bags

If all these activities combine, the *phoomdi* can be cleared in 10 years thereby restoring the lake to a state that was 200 years ago.

The nutrient regime of the lake should be so managed that the removal of *phoomdi* may not induce phytoplankton blooms in the lake and cause water quality deterioration. Nutrient management can be achieved

MANAGEMENT OF THE LOKTAK ECOSYSTEM: ANOTHER PERSPECTIVE

The management strategies for an ecosystem depend upon two basic considerations first, the kind of ecosystem and its natural functions and values, and second, the objectives of management itself Loktak lake has only recently been designated a Ramsar site i.e a Wetland of International Importance Is it a wetland today ? The construction of dams and barrages to regulate water flow is generally considered a major threat to the wetlands Has the Ithai barrage not destroyed (or at least altered) the Loktak wetland existing before its commissioning ? Does the altered wetland as we have now, have same functions and values that were associated with the system before the hydel scheme was implemented?

Assuming that the present Loktak lake is a wetland that we wish to conserve (and utilise sustainably) have we set out goals clear ? Is Loktak to be managed for irrigation and hydropower, for flood control, for fisheries, for *sangai* or for other natural resources or just for its special ecological features like *phoomdis*? Several of these objectives are not compatible with each other

It is true that the wetlands are generally associated with lakes and other open water habitats It is also possible that in the historical past Loktak was a large lake which gradually turned into what it was before 1983 All lakes senesce into marshes, meadows or turn into forests over a geological time scale Any kind of human management can only delay the process by decades

The main issue remains to be resolved Are wetlands and lakes the same? Do they have similar characteristics? Do they have similar functions? And can they be managed in the same manner? Why use different names for the same system? The US Fish & Wildlife Service Classification does not provide means to understand the ecological characteristics and functions of a wetland A majority of the wetlands are typically eutrophic' systems as they are highly productive and support large amounts of biomass and species diversity Typical peat bogs are the only 'oligotrophic" systems in as much as they are nutrient poor and least productive but rich in species diversity

On the other hand, lakes are typically species poor, nutrient poor, low in productivity and oligotrophic systems where any increase in nutrients and hence, in algal production (eutrophication"), is considered undesirable This is entirely related to the human use of the lake A fishery reservoir or fish pond has to be eutrophic or has to be made eutrophic As long as the increased primary production is readily converted to utilisable biomass of fish or is in the form of macrophytes, and the water can be used for drinking or recreation (i e free from algal blooms and pathogens) eutrophication remains acceptable

The authors of this booklet have treated Loktak as a typical lake and discussed its management based on an understanding of the science of lake management in temperate regions If Loktak is to be managed as a lake for hydropower and fisheries their discussion has great merit But then, Loktak will no more quality to be wetland and a Ramsar site

The large wetland complex of Loktak (which included the numerous *phats* on either side of Manipur river) has been converted into a reservoir It has lost its major wetland characteristics Removal of *phoomdis* will be the final blow

Phoomdis of Keibul Lampao cannot be sustained in isolation of the rest of the lake As soon as the Keibul Lampao area gets silted up and the *phoomdi* comes to rest upon the bed permanently it will no more be *phoomdi* It will turn into a typical terrestrial area

Phoomdis are interesting and characteristic of the Loktak area but by no means unique in the world They occur nearly throughout the tropics in southeast Asia, Africa and South America They differ only in the species that produce or occupy them Purely man-made floating islands of soil-vegetation -detritus mixture were described about a century ago from Dal lake Kashmir and are still there

Dr Brij Gopal
School of Environmental Sciences
Jawaharlal Nehru University

through a combination of different techniques like checking of nutrients inflow and enhancement of its outflow biotic harvesting and changing the catchment land use In Loktak lake the biotic harvesting and plantation of macrophytes capable of stripping nutrients will be very effective as many aquatic plants are

used as food and fodder by the local people. Besides, there is a large scope for biotic community manipulation in the lake so that a favourable food chain or food web may control the level of nutrients.

Management of the Catchment

Both the direct and indirect catchments of Loktak are constituted mainly of hills where tribal communities have the ownership and rights over the forests. The government cannot effectively interfere with the rights of the tribal chieftains. This hampers the introduction of scientific management of the lands. General suggestions like catchment afforestation, construction of check dams and settled cultivation as an alternative to shifting cultivation, alone will not work. A specially designed programme is to be developed that may wean away the tribals from their primitive style of landuse. Such a package has not surfaced yet.

Environmental Education and Legislation

Much is still to be done about educating people on what the lake means to them. A large section of the population around the lake have a cherished dream of a beautiful lake but want to convert it into fish farms and paddy fields. In this regard, even the local elite population is far from understanding the ecological significance of the lake. Everybody seems to maximize the output from the lake in varied terms. This problem has to be countered through education, proper legislation and enforcement.

Scientific Studies

Though the lake has been of interest to the politicians, naturalists and resource planners since a long time, there have been only a few studies which are at best fragmentary, incoherent and sometimes with even contradictory observations. The notable research projects include those undertaken by Bhatia (1979) and Tombi Singh (1991, 1992, 1993). Shyamananda (1991) recently made attempts at a comprehensive assessment of eutrophication of the lake and suggested measures for its ecological management. Fairly exhaustive information is now available on the flora and fauna of the lake. Studies have also been made on the basin morphometry, landuse in the catchment, water and sediment chemistry, and the productivity of phytoplanktonic communities. Based on these studies the ecological state of the lake can be described as 'highly eutrophic, senescent, P-limited system having macrophyte-phytoplankton mixed responsive pattern in a shallow, flat-bottomed, windswept, polymictic and diminutively stratified basin' (Shyamananda 1991). The lake ecosystem is of a sensitive type with a vast active bottom and in a precarious balance ready to tilt towards the unfavourable side in response to erratic human intervention.

Future Needs

Clearly, our present understanding of the lake system is inadequate. Much of the baseline data are still required. Studies on the production of planktonic, macrophytic, benthic and other animal communities are wholly lacking. The nutrient dynamics of the system is not known at all. Much is yet to be investigated about the point and non-point sources of nutrients and pollutants and the internal loading of nutrients. The inflow of silt needs to be properly estimated and the hydrology of the lake basin has to be reassessed.

Studies are also required on the functions and values of this wetland especially for the waterfowl and *sangai*, and factors affecting their decline.

Proper management of the lake requires an adequate understanding of the structure and dynamics of the whole system in place of ad hoc methods practiced today.

Baseline Data Collection, Monitoring and Research

All the given measures have to depend on a firm data base. A reliable data base can be established only by a well organised research and monitoring division of the management authority. Such a venture should not be half-hearted as the very fate of the project and also the fate of the lake lie with the data generated by the research and monitoring division. Since many unintended consequences are often encountered during the management operation of an ailing ecosystem, consistent monitoring of the ecosystem response to the ongoing operations is required.

Management Strategies

A detailed analysis of the management plans and possible alternatives is outside the scope of this report. Some suggestions are therefore summarized below.

- The management plan should incorporate established concepts, principles and practice of lake ecosystem management science for a risk free operation. A major shift of direction from the resource exploitative strategy towards ecological rehabilitation of the lake is needed.

- Instead of treating Loktak lake in isolation, other similarly threatened lakes, wetlands and drainage system of the southern Manipur valley should be taken into account for a holistic and comprehensive management. The Loktak Development Authority should be reconstituted as Lakes and Wetlands Management Authority by extending its activities simultaneously to all threatened lentic water bodies.

- The present plan aimed at gross physical modification of the entire lake with the construction of 126 km of dyke encircling the lake, bridges, causeways, canals, culverts and sluice gates, and destruction of hillocks and macrophyte stands en masse should be avoided.

- The unrealistic and costly major dredging operation should be reduced to selective dredging. More emphasis should be given to the clearance of *phoomdi* (70% of its total extent).

- Since direct intervention in the tribal landuse practices in the hilly catchment areas is not possible, meticulously designed package schemes should be prepared for the management of the catchment of Loktak and other lakes.

- Extreme care should be taken to preserve the flora and fauna, especially the migratory birds and the brow-antlered deer of Keibul Lamjao National Park. A special investigation into this aspect will be required.

- The spade work should include an active baseline data collection, research by a team of experts, revenue settlement of the lake boundary and bathymetric survey of the Loktak and other lakes and wetlands in the Manipur valley.

- Last but very important is the establishment of a permanent Research and Monitoring Division as a vital organ of the Lake Management Authority for reliable baseline data collection, ecosystem response monitoring and evaluation, consistent documentation, archiving and referral system, and interaction with national and international forums for collaboration and technology transfer. The management project should begin only as a sequel to it.

APPENDICES

APPENDIX IA - VARIOUS LAKES (SUB BASINS) OF LOKTAK LAKE

NORTH	AREA (ha)
Hirenkom pat	52
Tinphakom pat	49
Utra pat	41
Sana pat	81
WEST	
Birhari pat	38
Ngakara pat	32
Tekra pat	25
Moirangkom pat	
Tharlopokpi pat	81
Yena pat	120
Laisol pat	60
Awangsoi pat	59
Sumairou pat	57
SOUTH	
Takmu pat	516
Huibidak pat	108
Ungamen pat	230
EAST	
Khuljak pat	270
Thamnu-macha pat	315
Laphupat	190

APPENDIX IB - RIVERS AND STREAMS ASSOCIATED WITH LOKTAK LAKE BASIN

Stream	Drains into	Catchment Area (sq km)
NORTH		
Nambul	Loktak main	217.23
Nambol		124.60
Merakhong	Sanapat	
Kanakhong	Utrapat	
Kak	Utrapat	
Oinam	Awangsoipat	13.25
WEST		
Yumnam Khunou	Sumairou	
Keinou	Sumairou	9.85
Thongjaokhong	Awangsoi	
Kharok	Laisol	9.65
Kaiborok	Yenapat	12.50
Thabakhong	Yenapat	6.25
Thongjaorok	Tekrapat	20.98

Khujairok	(Thinungei)	13.75
Lamnganbi	(Thinungei)	
Awang	(Phubala)	
Khongdoubi	(Phubala)	
Pakhangkhong		
Sanathoibi	(Sanu Siphai)	3.95
Tera kunung	(Narang Saina)	
Mayangkhong		
Irumbikhong		5.35
Loklenkhong	Loktak main (Ngankha lawai)	

SOUTH

Moirang Lamkhai khong	
Loktak main (Moirang bazar)	
Thoibi khong	Takmu
Haogram khong	Takmu
Thangalawai khong	Ungamel
Kangsoibi khong	Ungamel
Moirang river	Loktak main (Moirang bazar)

EAST

The following flow both ways

Khordak channel
Ungamel channel
Komlakhong
Phoubakchao canal
Haiyen khong

APPENDIX IIA - MACROFLORA OF LOKTAK LAKE

TERRESTRIAL SPECIES

Latin name	Common Name	Local name
Achyranthes aspera Linn	chirchita	kavel khujil
Bauhinia malabarica Roxb	Malabar mountain ebony	chingthrao
B. purpurea Linn	camel's foot tree	do
Acacia farnesiana Willd	sweet acacia	
A. arabica Willd	gum tree (babul)	chingonglei
Albizzia odoratissima Benth	black siris	
Albizzia lucida Benth		khok
Mimosa pudica		
Maclura cochinchinensis (Lour.) Corner		
Ficus glomerata Roxb	fig	heibung
F. hispida L.f. Linn		ashi-heibong
Canthium gracipes Kurz		lam-heibi
Galium mollugo L.		
Leucas aspera Spreng		
Mosla ocymoides Buch. ex. Benth		
Datura suaveolens Willd	tree datura	sagoidak
Croton sapida Roxb		heitup
Lantana camara Linn		nongballei
Stachytarpheta indica Vahl	Aron's rod	
Clerodendron viscosum Vent		moiranf khanambi

Clerodendrum indicum (L) O Ktze	tube flower	kuthap angouba
Clerodendron glandulosum Coleb ex Wall		kuthap
Vitex negundo Linn	Chinese chaste tree	urikshibi
Vitex trifolia Linn		do-
Duranta repens Linn	golden dew drop	samballei
Wendlandia glabrata DC		pheija
Impatiens balsamina Linn	balsam	khujang
Impatiens tomentosa Heyne		khujang
Bombax malabaricum DC	red silk cotton	tera
Salix tetrasperma Roxb	willow	uyum
Rhus hookeri Sahni & Bahd		heimang
R semilata Murr		heimang
Spondias pinnata Kurz	Indian hogplum	heining
Pinus kesia Royle ex Gordon	Khasi pine	uchan
Aeschynomene aspera Linn	sola pith	chingongleirangouba
Amaranthus spinosus Linn	prickly amaranth	chengkruk
		tingkhang pamba
Amaranthus tricolor Linn	amaranth	do-
A viridis Linn		chengkruk
Celosia argentea Linn		
Artemisia nilagirica (Clarke) Pamp		laibak ngou
Ageratum conyzoides Linn	goatweed	khongjainapi
Erigeron bonariensis Linn		
Erigeron multiradiatus Benth		
Grangea maderaspatana (Poir) DC		
Gynura cusimbua (D Don) Moore		leirapaibi
Helianthus annuus Linn	sunflower	numitlei
Laggera pterodonta Benth		
Senecio densiflorus Wall ex Hook		
Senecio saxatilis Wall ex DC		
Tridax procumbens Linn		shampakpi
Vernonia bracteata Wall ex C B Clarke		
Vernonia patula (Dryand) Merrill		
Xanthium strumarium Linn	cockle bur	hameng sampakpi
Heliotropium ovalifolium Forsk		
Cassia bicapsularis Linn		thaonam
Cassia didymobotrya Fresen		
Cassia hirsuta Linn		
Cassia laevigata Willd		
Cassia occidentalis Linn	western senna	
Cassia sophera Linn		
Cassia tora Linn	foetid cassia	
Stellaria media Linn	chick weed	yerum keirum
Commelina obliqua B Ham ex D Don		
Euphorbia hirta Linn		pekang leiton
Euphorbia thymifolia Burm		lengnou
Phyllanthus debilis Ham		
Desmodium heterophyllum DC		
Desmodium gyrans	Indian telegraph plant	sampakpi
Sesbania sesban (Linn) Merr	common sesban	chu-chu ramei
Urena lobata Linn	aramina/cadillo	sampakpi
Mimosa pudica Linn	sensitive plant	kangphal/Ekaithabi
Ardisia solanacea (Poir) Roxb		
Dactyloctenium aegyptiacum (L) Beauv		pungphai

Lindernia anagallis (Burm.) Pennell		
Solanum khasianum C. B. Clarke	-	sing-khanga
Solanum nigrum Linn	black night shade	leipung khanga
Solanum myriacanthum Dunal		lam-khamen
Triumfetta annua (Linn.)		
Triumfetta rhomboidea Jacq	spiny cockle	
Triumfetta tomentosa Noronha		
Plantago erosa Wall		yempat
Centiana tenella Rottb		
Canna flaccida Sal.		laphurit Hangampan
Canna indica Linn	Indian shot	laphurit angangba

AQUATIC AND MARSH SPECIES

Free-Floating Macrophytes

Eichhornia crassipes (Mart.) Solms	water hyacinth	kabokang
Azolla pinnata R.Br.	water fern/water velvet	kang macha
Salvinia natans Hoffm	velvet weed	kang-macha
S. cucullata Roxb	water fern	kang-macha
Pistia stratiotes Linn	water lettuce	kangjao
Utricularia flexuosa Vahl	bladderwort	chiring kokphabi
Lemna trisulca Linn		kang macha
Ricciocarpus natans Linn		kang macha
Riccia natans Corda O. Kuntze		kang macha

Floating leaved Macrophytes

Nelumbo nucifera var. alba Roxb	white lotus	thambal angouba
Nelumbo nucifera var. rubra Roxb	red lotus	thambal angangba
Euryale ferox Salisb	gorgon nut/fox nut	thangjing
Nymphaea micrantha Guill. & Perr	water lily	nilakamal
Nymphaea nouchali Burm	red water lily	thariktha angangba
Nymphaea pubescens Willd	water lily	tharo
Nymphaea rubra Roxb	red water lily	tharo angangba
Nymphaea stellata Willd	blue water lily	thariktha
Nymphoides cristata (Roxb.) O. Kuntze	snow flake	tharo macha
Nymphoides indicum (Linn.) O. Kuntze		ngachak komol
Nymphoides hydrophyllum (Lour.) O. Kuntze		tharo macha
Neptunia prostrata (Lamk.) Bail		ishing ikaithabi
Marsilea minuta Linn		ishing vensang
Marsilea quadrifoliata Linn	four leaved water clover	ishing yensang
Trapa natans var bispinosa Linn	water chestnut	heikak
Potamogeton nodosus Poir	pondweed	

Submerged Macrophytes

Hydrilla verticillata (L.f.) Royle	hydrilla	charang
Nechamandra alternifolia (Roxb.) Thw		
Ottelia alismoides Pers		
Vallisneria spiralis Linn	eel grass	lairenchak
Hydrolea zeylanica (L.) Vahl		charang
Ceratophyllum demersum Linn	coontail/hornwort	charang nakuppi
Potamogeton crispus Linn		
Potamogeton lucens Linn		
Potamogeton pectinatus Poir		

Potamogeton pusillus Linn		
Najas graminea Del		
Najas minor All		
Emergent Macrophytes		
Alisma plantago aquatica Linn	water plantain	kakthrum
Ceratopteris thalictroides Brogn		ishing yempat
Ranunculus sceleratus Linn	Indian buttercup	lallu cauba
Monochoria hastaefolia Presl		kakhi
Monochoria hastata (L) Solms		lobok ing lhi
Sagittaria sagittifolia Linn		koukha
Sagittaria guayanensis HBK	arrowhead	koukha
Sagittaria sinensis Linn	arrowhead	koukha
Oryza rufipogon Griff		wainu chara
Oryza sativa Linn	rice/paddy	phou
Hemiphragma heterophyllum Wall		
Limnophila connata (Buch Ham) Pennel		
Limnophila sessiliflora (Vahl) Bl		
Limnophila rugosa (Roth) Merrill		
Hygrophila aristata (Retz) Nees		
Marsh species		
Butomopsis lanceolata Kunth		
Caldesia parnassifolia Linn		
Alternanthera sessilis (Linn) R Br		phakchet
A repens (Linn) O Ktze		
Achyranthes aquatica R Br		
Alternanthera philoxeroides (Mart) Griseb		kabo-napi
Siegesbeckia orientalis Linn		shampakpi
Sphaeranthus indicus Linn		
Cynoglossum furcatum Wall		
Drymaria cordata Willd		Lindan mathi
Polycarpon indicum (Retz)		
Commelina appendiculata C B Clarke		wanding khoibi
Commelina benghalensis Linn	day flower	
Commelina paludosa Bl		
Cyperus brevifolius (Rottb) Hask		chumthang
Cyperus corymbosus Rottb		
Cyperus difformis Linn		
Cyperus globosus Allhom		
Cyperus rotundus Linn	nutsedge motha grass	
Cyperus platystilis R Br		
Eriocaulon truncatum F Ham x Mart		
Eriocaulon sieboldianum Seib & Zuc		
Euphorbia hirta Linn		pekang lhiton
Limnophila cordifolia (Colsm) Merr		
Limnophila viscosa Willd		
Centella asiatica (L) Urban	Indian pennywort	peruk
Hydrocotyle javanica Thunb		lai peruk
Hydrocotyle sibthorpioides Lamk		
Ludwigia clavellina Gomez de la Manza		ishing kundo
Ludwigia octovalvis var *sessiliflora* Raven (Mich)		debo
Ludwigia parviflora Roxb		ishing kondol
Equisetum debile Roxb ex Vaucher	horsetail	lai utong

Lygodium japonicum (Thumb) S W		
Pteridium aquilinum (Linn) Kuhn		lai-chakhrung
Pteris cretica Linn		
Pteris quadriaurita Retz		
Sphenomeris chinensis Linn		
Selaginella amphyphylla Alston		
Acorus calamus Linn	sweet flag	ok-hidak
Alocasia indica (Roxb) Schott		pallukabi
Colocasia esculenta (Linn) Schott	taro (common arum)	lamphal
Adenostema lavenia (Linn) O Kuntze		
Anaphalis cinnamonia C B Clarke		
Anaphalis araneosa DC		
Blainvillea acmella (Linn) Phill		
Crepis silhetensis Hook		
Dichrocephala latifolia DC		lallukok
Eclipta prostata Linn		uchi-shumbal/ phumkhokchang
Eclipta alba Linn		
Enhydra fluctuans Lour		comprek tujombi
Mikania micrantha Kunth		uri-hingchabi
Sonchus wightianus DC		khomthokpi
Polycarpon indicum (Retz) Merr		
Argyreia nervosa (Burm f) Boj		uri-tujombi
Evolvulus nummularius Linn		
Alpinia galanga (L) Willd	sheel ginger	pullei
Alpinia nigra Gaertn		pullei
Ipomoea aquatica Forsk		
Ipomoea cairica (Linn)		
Ipomoea quamoclit Linn		
Costus speciosus (Koen) Smith		khongban takhellei
Hedychium coronarium Koenig	ginger lily	loklei
Hedychium spicatum Buch-Ham	spiked ginger lily	takhellei
Benincasa hispida (Thunb) Cogn	ash gourd/ wax gourd	torbot
Bryonopsis laciniosa Naud		kwakthabi
Coccinia indica Wight & Arn	ivy gourd	tayal
Carex cruciata Wahl	slough grass	humdang
Cyperus digitatus		
Fimbristylis aestivalis Vahl		
Scirpus strimarium L		
Carex sp		
Dioscorea alata Linn	white yam	ha
Dioscorea bulbifera Linn		phum ha
Dioscorea glabra Roxb		phum-ha
Croton bonplandianum Baill		
Glochidion multiloculare Voigt		
Aeschynomene aspera Linn		
Crotalaria alata F Ham ex Roxb		lamhawai
Crotalaria juncea Linn		u-hawai-maton
Abelmoschus esculentus (L) Moench	lady s finger	bhelandri
Sida acuta Burm		
Sida rhombodifolia		
Thespesia divericata DC		
Triumpheta rhomboidifolia		
Tridax procumbens		

Arundo donax L	giant reed	luwang tou
Coix aquatica Roxb		
Coix lachryma-jobi Linn	job's tears	chaning
Cymbopogon nadus (L) Rendle	citronella grass	haona charot
Cynodon dactylon (L) Pers	durba grass	tingthou
Echinochloa stagnina Retz		hup
Erianthus arundinaceus (Retz) Jeswiet		singmut
Erianthus procerus (Roxb) Raizada		singnang
Hymenachne assamica Hitch		
Imperata cylindrica Linn		ee
Isachne himalaica Hook		hup-laba
Leersia hexandra Sw		choura
Narenga porphyrocoma (Hance) Bor		singmut
Oryza rufipogon Grift		wainuchara
Panicum paludosum Roxb		
Paspalum scrobiculatum Linn		
Phragmites karka (Retz) Trin	nodding reed/reed	tou / tourel
Polytoca digitata (L f) Druce		
Saccharum munja Roxb		khoimom
Saccharum spontaneum Linn	*thatch grass*	*mom*
Sacciolepis myosuroides (R Br) Camus		*hup*
Setaria pallidefusca Schum	*cattail millet*	*hup*
Zizania latifolia (Turcz) Hand-Mazz		*ishing kambong*
Oryza perennis		
Oryza minuta		
Capillipedium sp		
Eragrostis gangetica		
Axonopus sp		
Persicaria chinensis (L) Gross		*yengkhuman/lelbung tharam*
Persicaria perfoliata (L) Gross		*lilhar*
Persicaria posumbu Buch -Ham ex D Don		*ishing kengoi*
Polygonum barbatum Linn		*yellang*
Polygonum lapathifolia (L) S F Gray		chakhong manba
Polygonum orientale Linn	Oriental pepper	chakhong
Polygonum plebeium R Br	Alpine knot weed	phakchet
Rumex maritimus Linn		torong khongchak
Rumex nepalensis Spreng		torong khongchak
Rumex vesicarius Linn	bladder dock	torong khongchak
Cynotis barbata		
Lysimachia javanica Bl		
Oenanthe javanica (Bl) D C	drop wort	komprek
Ammannia multiflora Roxb		

Source Tombi Singh (1991)

Appendix II B PHYTOPLANKTON SPECIES FOUND IN LOKTAK LAKE 1985-86

A Chlorophyceae
Chlamydomonas sp
Volvox sp
Ulothrix sp
Staurastrum sp
Oedogonium sp
Scenedesmus sp
Ankistrodesmus sp
Tetradesmus sp
Pediastrum sp
Oocystis sp
Chlorella sp
Botryococcus sp

B Myxophyceae
Anabaena sp
Chroococcus sp
Coelosphaerium sp
Nostoc sp
Microcystis sp
Spirulina sp
Merismopedia sp
Oscillatoria sp
Phormidium sp
Aphanizomenon sp

C Bacillariophyceae
Melosira sp
Cyclotella sp
Fragilaria sp
Synedra sp
Asterionella sp
Navicula sp
Cymbella sp

D Euglenophyceae
Euglena sp
Trachelomonas sp
Phacus sp

Source: *Shyamananda (1991)*

Appendix II C IMPORTANT PLANT SPECIES THAT COLONIZE THE *PHOOMDI*

Most of the plants occurring in the Loktak Lake and its surroundings grow on the *phoomdis* as well. Some of the more important species are:

S.N.	Scientific Name	Local Name
1	*Sacciolepis myosuroides* R. Br.	hup
2	*Echinochloa stagnina* Retz	hup
3	*Leersia hexandra* Sw.	chouri
4	*Setaria pallidefusca* Schumach.	hup
5	*Azolla pinnata* R. Br.	kang macha
6	*Salvinia natans* Hoffm.	-do-
	Salvinia cucullata Roxb.	-do-
8	*Pistia stratiotes* Linn.	kangjao
9	*Eichhornia crassipes* Mart.	kabokang
10	*Ipomoea aquatica* Forsk.	kolamni
11	*Jussiaea repens* Linn.	esing kondol
12	*Monochoria hastaefolia* Presl.	kakhi
1	*Monochoria hastata* (L.) Solms	kabokang labi
14	*Polygonum barbatum* Linn.	yellang
15	*P. orientale* Linn. Chakhong	
16	*P. posumbu* Buch.-Ham. ex D. Don	do

17	*P. plebejum* R. Br.	phakchet
18	*Persicaria chinensis* (L.) H. Gross	yengkhuman
19	*P. perfoliata* Linn. H. Gross	lilhar
20	*Rumex nepalensis* Spreng.	torong khongchak
21	*R. Maritimus* Linn.	-do-
22	*R. vesicarius* Linn.	-do-
23	*Cyperus difformis* Linn.	chumthang manbi
24	*Cyperus rotundus* Linn.	chumthang
25	*Arundo donax* Linn.	luwang tou
26	*Phragmites karka* Retz. Trin.	tourel (tou)
27	*Cynodon dactylon* Linn. Pers.	tingthou
28	*Erianthus procerus* Roxb.	singnang
29	*Erianthus arundinaceus* Retz.	singmut
30	*Zizania latifolia* Turcz.	ising kambong
31	*Imperata cylindrica* Linn.	ee
32	*Saccharum spontaneum* Linn.	mom
33	*Saccharum munja* Robx.	khoumom
34	*Carex indica* Linn.	hundang
35	*Coix lacryma-jobi* Linn.	chaning
36	*Alpinia galanga* Linn.	pullei
37	*A. nigra* Gaertn. -do-	
38	*Hedychium coronarium* Koenig	loklei
39	*Oenanthera javanica* (BL.)	komprek
40	*Cymbopogon nardus* Linn. Rendle	haona (charot)
41	*Desmodium motorium* Merr.	Iamhawai
42	*Crotalaria juncea* Linn.	urihawai maton
43	*C. alata* L. Ham. Lamhawai	
44	*Enhydra fluctuans* Lour.	komprek tujombi
45	*Mikania micrantha* Kunth	uri hingchabi
46	*Alternanthera philoxeroides* Mart. Griseb.	kabo napi
47	*Colocasia esculenta* Linn.	lampal
48	*Argyreia nervosa* Burm. f. Boj.	uri tujombi

Note: Species at SN 1–13 contribute also to the initial formation of *phumdi*

APPENDIX III A - LIST OF ZOOPLANKTON SPECIES FOUND IN LOKTAK LAKE (1985-86)

Protozoa

Arcella vulgaris
Arcella megatsoma
Actinosphaerium sp
Acanthocystis sp
Amoeba sp
Difflugia sp
Euglypha sp
Paramoecium sp
Didinium nasutum
Vorticella companula

Cladocera

Alona affinis
Bosmina longirostris
B coregoni
Daphnia magna
D rosea
D pulex
Chydorus sp
Sida sp
Pseudosida bidentata
Simocephalus expinosus
Pleuroxus denticulatus
Diaphanosoma sp

Rotifera

Polyarthra vulgaris
Epiphanes
Asplanchna sp
Cephalodella sp
Brachionus sp
Filinia opoliensis
Keratella cochlearis
Keratella valga
Synchaeta pectinata
Mytilina mucronata
Platyias sp
Lecane sp
Monostyla sp
Diplois sp

Copepoda

Trichocera sp
Bryocamptus sp
Cyclops bicuspidatus
Cyclops vernalis
Cyclops bicolor
Cyclops scutifer
Eucyclops agilis
Mesocyclops hyalinus
Mesocyclops leuckarti
Diaptomus sp

Source Shyamananda (1991)

APPENDIX - III B MACROFAUNA OF LOKTAK LAKE (SOURCE TOMBI SINGH, 1992)

I INVERTEBRATES

(a) ANNELIDA

Haemadipsa zeylanica agilis Moore
Haemadipsa zeylanica zeylanica Moquin-Tandon
Hirudinaria (Poecilobdella) *granulosa* Savigny
Hirudinaria javanica Wahlberg**
Pheretima posthuma Fn Br
Nais linguish Muller
Nais communis Piquel
Stylaria fossularis Leidy
Branchiura sowerbyi Bedd
Pristina acquiseta Bourn
Dero dorsalis Stephenson
Chaetogaster langi Breastcher
Aulophorus furcatus Muller
Tubifex tubifex Muller
Lymnodrilus socialis Stephenson
Aeolocnima bengalensis Stephenson

(b) ARTHROPODA

Acherontia lachanis Fabr
Acheta domesticus
Acilius sulcatus
Acisoma panorpoides
Acrida exaltata Walker
Acridium melanocorne

Aeschna
Afidenta mimetica Dicke
Amsecta moorei Butler
Anopheles ahomi Chowdhury
Apis indica
Apis mellifera
Araneus diadematus
Argyroneta aquatica
Atractomorpha crenulata Fabricius
Aularches milliaraia Linn
Ballia eucharis Mulsant
Belostoma indicum Lep & Serv
Berosus indicus
Berosus pulchellus MacLeay
Brachytrypes portentosus Lichtenstein
Cancer sp
Chilocorus nigritus Fabr
Chorthippus parallelus
Chrococdocus rubusta Serville
Chrysis orientalis Gues
Cnaphalocrocis medinatis Guen
Coccinella transversalis Fabricius
Coelophora bisellata Mulsant
Componatus sp
Coptotettix artolobus Hancock
Cratalonotus ganges Linn
Culex edwardsi Barraud
Culex sinensis Theobald
Cybister confusus Sharp
Cybister convexus Sharp
Cybister posticus Aube
Cybister tripunctatus asiaticus Sharp
Danais limace Gramer
Danais chrysippus Linn
Dendrolimus sps
Diacretus leucopterus Haliday
Diplonychus Sphaerodema rusticum Fabr
Discrisia obliqua Walk
Dytiscus marginalis Linn
Dytiscus sp
Euthelio garudo Moor
Epilachna dcodecastigma Weidemann
Epilachna manipurensis Kapur
Eretes sticticus Linn
Ergolis merione Gram
Eusoma adulatrix Kollar
Excelastis atomosa Wals
Forficula auricularia
Gangara thyrsis I M N
Gesonula punctifrons Stal
Gelastorrhius filatus Walk
Gerris gibbifer
Geris najas
Gryllotalpa africana
Gryllotalpa gryllotalpa
Gryllotalpa fossor Scudder
Gryllus compestris
Gyrinus marinus
Gyrinus natator Linn
Gyrinus sp
Harmonia arcuata Fabricius
Harmonia octomaculata Fabr
Hemodula westwoodi
Hezmannia complex
Hydaticus fabricii
Hydaticus vittatus Fabr
Hydrophilus caraboides
H. olivaceous Fabr
H. piceus
H. spinditus Bedel
Hypolimnus sp
Junonia almana Linn
J. lemonias Linn
Labia minor
Laccotrephes branchialis
La maculatus Fabricius
Lexis dimidiata Febr
Lemnia biplagiata Swartz
Lithurgus stratus Smith
Lysiphlebus japonica Ashmead
Megapolistes olivaceous De Geer
M. rothneyi
Melanitis ismena Gram
Menochilus sexmaculatus Febr
Mentis religiosa
Morgerina indica Sounders
Neopancsia manipurensis sp
Nemobius sylvestris
Nepa cinera
N. rubra
Neptis crynome Westwood
N. hylus Moore
Notonecta glauca Linn
Notonecta glauca Linn
Nymphula depunctalis
Oecophyla smaragdina Fabr
Oenopia luteopustulata Mulsant
Oxya chinensis Thumb
O. hylahyla Serv
Palaemon carcinous
P. malcolsoni
Parnera mathias Fabr
Phlacoba infumata Brunner
Pieris brassicae
P. rapae Linn
Pieris sp
Platy pleura machinoni
Polistes sagillarius Sauss

Polybia orientalis Sauss
P. stigma Smith
Ponera sp
Polyrhachis mayri Roger
Precis atlites Linn
P. polytes
Ranatra elongata Fabricius
R. linearis
Regumbertica attenuata Fabr
Rhantaticus congestus Klug
Rhinchium brunneum Sauss
Salius aureosericeus Guer
Sandracottus manipurensis Vazirani
Scirpophaga nivella Fabr
Scolia capitata Guer
Scymnus japonicus Weise
S. kawamurai Ohta
Spathosternum prasiniferum Walk
Sternolophus rufipes Fabr
Sympetrum striolatum
Synonycha grandis Thunberg
Syntomis sperbius
Tagasta indica Bolivar
Tegenaria ferruginea
Teleogryllus occipitalis Serville
Tettigonia viridissima
Trilophidia annulata Thunberg
Tripteroides tripteroides indicus Barraud
Tryporyza incertulas Walk
T. innotata Walk
Vespa magnifica
Virachola isocrates Fabr
Xanthopimpla sp
Xylocopa sp
Zeuzera coffeae Nieta

(C) MOLLUSCA
Lymnaea sp
L. ovata Drap
L. stagnalis
Pila sp
P. globosa Swainson**
Planorbis corneus Linn
Planorbis planorbis
*Unio marginalis***
Viviparara bengalensis Lamarck
V. oxytropis Benson

II VERTEBRATES

(a) PISCES (FISHES)
Acanthopthalmus pangia Ham
Amblypharyngodon mola Ham
Barilius barna Ham
B. bendelisis Ham
B. bola Ham
B. gatensis Val
B. guttatus Day
Catla catla Ham
Cirrhinus mrigala Ham
C. reba Ham
Crossocheilus burmanicus Hora
C. latius latius Ham
Cyprinus carpio var. *nudus* Bloch
C. carpio var. *communis* Linn
C. carpio var. *specularis* Lacepede
Ctenopharyngodon idella Val
Esomus altus Blyth
E. danricus Ham
Garra gravelyi Ann
Hypophthalmichthys molitrix Val
Labeo angra Ham **
L. bata Ham **
L. calbasu Ham
L. dero Ham **
L. gonius Ham
L. rohita Ham
Osteobrama belangeri Val **
O. cotio cotio Ham
O. cotio cunma
Puntius chola Ham
P. conchonius Ham
P. puntio Ham
P. sarana Ham
P. ticto ticto Ham **
P. sarana orphoides Ham
Botia hymenophysa Bleeker
Lepidocephalus guntea Ham
Nemacheilus sikmaiensis Hora**
Notopterus chitala Ham
N. notopterus Pallas
Aorichthys seenghala Sykes**
Mystus bleekeri Day
M. cavasius Ham
Ompok bimaculatus Bloch
O. pabo Ham
Wallago attu Schn
Bagarius bagarius Ham **
Gagata cenia Ham **
Glyptothorax trilineatus Blyth
Clarias batrachus Linn
Eutropiichthys vacha Ham **
Heteropneustes fossilis Bloch
Channa orientalis Schn
C. punctatus Bloch
C. striatus Bloch**
Anabus testudineus Bloch
A. oligolepis Bloch

Colisa faciatus Bloch
C. sota Ham
Chanda nama Ham
Glossogobius giuris Ham
Tilapia mossambica P & T
Chanda ranga Ham
Monopterus albus Zuiew

(b) AMPHIBIA

Bufo melanostictus Schneider	true toad	hangoi porabi
*Hyla arborea***	tree frog	hangoi tangsag
*Polypedates leucomystax***	tree frog	hangoi tangsang
Rana tigrina Daudin	Indian bull frog	moreh hangoi
Rana limnocharis Wiegmann	paddy field from	hangoi konde
Rhacophorus leucomystax Gravenhorst**	chunam frog	hangoi sempak

(c) REPTILIA

Ahaetulla nasuta Lacepede**		
Amphiesma stolata Linnaeus	striped keelback	lilhi
Bungarus caeruleus Schneider		
B. faciatus Schneider		
Calotes versicolor Daudin		
Chrysopelea ornata Shaw		
Dendrelaphis tristis Daudin		
Elaphe radiata Schlegel	copperhead	tanglei wachetmanbi
E. helena Daudin		
Lycodon aulicus Linnaeus**		
Lycodon jara Shaw	yellow striped wolfsnake	narin
Nabuma sp		
Naja naja Linnaeus	Indian cobra	kharou
Naja sp	ishing kharou	
Natrix subminiata Schlegel	red necked keel back	tanglei kokngangbi
Oligodon albocinctus Cantor		lilkhak
Oligodon arnensis Shaw		
Oligodon cyclurus Cantor**		lilkhak
Oligodon erythrorhachis Jerdon**		
Opheodrys doriae Boulenger		narin
Ptyas korros Schlegel	Indo Chinese ratsnake	tanglei
Ptyas mucosus Linn	ratsnake	tanglei
Python molurus Linn *	Indian python	lairen
*Testudo elongata***		
Trimeresurus albolabris Gray**		kambong naril
T. erythrurus Cantor		naril
T. gramineus Shaw**		
T. monticola Gunther**		lindu charang
Typhlops braminus Daudin		
Varanus salvator Laurenti		
Vipera russelli Shaw **	Russel's viper	lindu senkhaimanbi
Xenochrophis piscator Schneider	checkered keelback	lillabop

(d) AVES (BIRDS)

Acridotheres tristis tristis Linn	Indian myna	chonga angangbi
Aegithina tiphia Linn	common iora	shaubeiga
Alauda gulgula Franklin**	lesser skylark	tinkhaklen
Amaurornis phoenicurus phoenicurus Pennant	white breasted water hen	uren-konthou
Anas acuta Linn	pintail	*meitungnga*

Anas clypeata Linn	shoveller	nganu-khara
Anas crecca crecca Linn	common teal	nganu-surit
Anas penelope Linn	wigeon	thangongmal
Anas poecilorhyncha poecilorhyncha J R Foster	spotted bill duck	nganu-khara
Anas querquedula Linn	blue winged teal	surit angouba
Anas strepera strepera Linn	gadwall	nganu thoidingnam
Anser anser rubrirostris Swinhoe	eastern graylag goose	metunga
Anser indicus Latham	bar headed goose	lam kanga
Ardea alba modesta J E Gray	eastern large egret	loklenba
Ardea cinerea Linn	grey heron	ushai
Ardeola bacchus Bonaparte	Chinese pond heron	urok lamprai
Ardeola grayii Sykes	Indian pond heron	urok lamprai
Aythya ferina Linn	common pochard	iruppi
Aythya nyroca Gulden Stead	white eyed pochard	iruppi
Bambusicola fytchii hopkinsoni ***	Assamese bamboo partridge	wakrek godwin-austen
Batrachostomus hodgsoni hodgsoni G R Gray***	hodgson's frogmouth	sumbong
Buteo buteo japonicus Temm & Schleg	buzzard	umaibi
Bubo flavipes Hodgson	tawny fish owl	
Bubo nepalensis nepalensis Hodgson	forest eagle owl	urak maku ningthou
Bubulcus ibis Linn	cattle egret	sandung il
Centropus sinensis intermedius Hume	crow pheasant	nongoubi
Ceryle rudis leucomelanura Reichenbach	pied kingfisher	ngarakpi
Columba pulchricollis Blyth	ashy wood pigeon	lam-khunu
Corvus macrorhynchos levaillantii Lesson	eastern jungle crow	kwak
Coturnix coturnix coturnix Linn	common grey quail	sorbol
Coturnix coturnix japonica Temm & Schleg	Japanese grey quail	sorbol
Dendrocygna javanica Horsfield	lesser whistling teal	tingi
Dendrophasa bicincta bicincta		
Dicrurus annectans Hodgson	crow billed drongo	charoi
Dicrurus hottentottus hottentottus Linn	spangled drongo	charoi
Dicrurus adsimilis albirictus Hodgson	north Indian black drongo	charoi
Ducula aenea sylvatica Tickell	green imperial pigeon	ching-khunu
Ducula badia griseicapilla Walden	grey-headed imperial pigeon	lam-khunu
Egretta garzetta Linn	little egret	urok
Egretta intermedia intermedia Wagler	median egret	langkhongsang
Enicurus leschenaulti indicus Hartert	leschenault s forktail	uchinao
Enicurus schistaceus Hodgson	slaty backed forktail	uchinao
Ephippiorhynchus asiaticus Latham	black necked stork	tharoichabi
Excalfactoria chinensis chinensis		
Falco biarmicus jugger J F Gray***	lagger falcon	khunnu-kharang
Francolinus francolinus Linn	black francolin	urel
Francolinus francolinus melanonotus Hume	Assam black partridge	urembi
Francolinus pintadeanus phayrei Blyth	Burmese francolin	kabo urembi
Fulica atra atra Linn	coot	nganu-porom
Gallicrex cinerea cinerea Gamelin	water cock	uthum
Gallinago gallinago gallinago Linn	fantail snipe	cheklaobi
Gallinago solitaria solitaria Hodgson	eastern solitary snipe	cheklaobi
Gallinula chloropus indica Blyth	Indian moorhen	urel
Gallus gallus spadiceus Bonnaparte	Burmese red jungle fowl	layel
Gracula religiosa intermedia A Hay	northern hill myna	chonga amubi
Grus monacha Temminck ***	hooded crane	wainuman
Grus sharapu Blanford	Burmese sarus	wainuren
Halcyon smyrnensis Linn	smyrna kingfisher	ngarakpi

Hirundo daurica Linn	Daurian swallow	sembang
Macropygia unchall tusalia Blyth	bar-tailed cuckoo dove	lam-khunu
Metopidius indicus Latham	bronze winged jacana	thammachabi
Milvus migrans Boddaert	black kite	umaibi
Milvus migrans govinda Sykes		
Monaracha zurea Boddaert	black naped blue fly catcher	khambrangchak
Motacilla caspica Gamelin	grey wagtail	khambrangchak
Motacilla citreola Pallas	yellow headed wagtail	khambrangchak
Motacilla maderaspatensis Gmelin		
Motacilla alba Linn	white pied wagtail	khambrangchak
Muscadivora aenea sylvatica		
Netta rufina Pallas	red crested pochard	iruppi
Nettapus cormandelianus Gmelin	cotton pygmy goose	pedrakot
Nycticorax nycticorax nycticorax Linn	night heron	chongkhu
Oenopopelia tranquebarica humilis		
Oriolus oriolus kundoo Sykes		
O. zanthornus zanthornus Linn		
Passer domesticus indicus Jardine & Selby		
P. rutilans intensior Rothschild	yunnan cinnamon tree sparrow	watrak-sendang
Pelecanus onocrotalus Linn	white or rosy pelican	uphong
Perdicula manipurensis manipurensis Hume	Manipur painted quail	sorbol amuba
Picoides cathpharius pyrrhothorax Hume		
Pluvialis dominica fulva Gmelin	eastern golden plover	nonging
Polyplectron bicalcaratum bakeri Lowe	Bhutanese peacock pheasant	lavel
Porphyrio porphyrio Latham	Indian purple moorhen	umu
Psittacula cyanocephala Linn		
Psittacula eupatria Linn		
P. krameri Scopoli***		
Pycnonotus jocosus monticola Linn	Assam red whiskered bulbul	khoiming
Rhodonessa caryophyllacea Latham****	pink headed duck	nganu kokngangbi
Rostratula benghalensis benghalensis Linn	painted snipe	kangdruk
Sarcogyps calvus Scopoli***		
Scolopax rusticola rusticola Linn	woodcock	sabal kang-druk
Sphenocercus apicaudus		
Spilornis cheela cheela Latham	crested serpent eagle	umaibi linphabi
Streptopelia chinensis Scopoli	spotted dove	lam khun
Streptopelia orientalis agricola Tickell		
Streptopelia orientalis meena Sykes	western turtle dove	lam-khunu
Streptopelia xanthocycla		
Sturnus contra superciliaris Blyth	Burmese pied myna	chonga arangbi
Sturnus malabaricus Gmelin	grey head myna	chonga
Sturnus pagodarum Gmelin	black head myna	chonga
Syrmaticus humiae humiae Hume		
Tadorna tadorna linn	common shelduck	nganu chinngangbi
Tadorna ferruginea Pallas	ruddy shelduck	nganu thangong
Treron apicauda Blyth	pin-tailed green pigeon	lam-khunu
Treron bicincta bicincta Jerdon	Indian orange breasted green pigeon	lam-khunu
Treron curvirostra nipalensis Hodgson	thick-billed green pigeon	lam khunu
Treron pompadora phayrei Blyth	ashy headed green pigeon	lam-khunu
Tringa totanus eurhinus Oberholser	eastern red shank	ngahoibi
Turnix maculatus maculatus		
Turnix sylvatica dussumieri Temminck	little bustard quail	sorbon
Turnix suscitator blumbipes Hodgson	Burmese bustard quail	sorbon

Turnix tanki tanki Blyth	Indian yellow legged button quail	sorbon
Tyto alba Scopoli	white owl	irak maku
Tyto alba stertens Hartert	Indian barn owl	irak maku
Upupa epos longirostris Jerdon**	Burmese hoopoe	sangairaba
Vanellus cinereus Blyth	grey headed lapwing	salang
Vanellus indicus atronuchalis Jerdon	Burmese red wattled lapwing	salangkak

(e) MAMMALIA

Aonyx cinerea Erxleben***	clawless otter	shanamba
Arctonyx collaris F. Cuvier***	hog badger	
Axis axis Erxleben	chital/spotted deer	
A. porcinus Zimmermann	hog deer	kharsa
Canis lupus Linn ***	Indian wolf	
Cannomys badius Hodgson	bay bamboo rat	shabi
Cervus eldi eldi McClelland ***	brow antlered deer	sangai
Cuon alpinus Pallas***	Indian wild dog	huithou
Felis catus		
F. chaus Guldenstaedt **	jungle cat	lam houdong
F. sylvestris		
F. temmincki Vigors & Horsfield***	golden cat	tokpa
Funambulus pennati Wroughton	five striped squirrel	kheiroi
Golunda ellioti Gray	Indian bush rat	uchi
Lutra lutra Linn	common otter	shanamba
L. perspicillata I. Geoffroy	smooth Indian otter	shanamba
Manis crassicaudata Gray **	Indian pangolin	
Melogale moschata	ferret badger	
Muntiacus muntjak Zimmermann	barking deer	shaji
Mus booduga Gray	common Indian field mouse	uchi
Mus musculus Linn. *personata*	house mouse	uchi
Mustela erminea Linn ***	ermine	shadung
Paradoxurus hermaphroditus	common palm civet	
Rattus rattus rattus Linn	common house rat	uchi
Ratufa bicolor Sparrman	Malayan giant squirrel	kheirobi achouba
Sus scrofa Linn	wild pig	lamok
Talpa micrura	eastern mole	utin
Viverra zibetha	large Indian civet	moirang sathibi achouba
Viverricula indica	small Indian civet	moirang sathibi macha
Vulpes bengalensis Shaw	common fox	lamhui
V. vulpes Linn **	red fox	lamhui

Rare species
Rare occurrence in Loktak Lake
*** Endangered species protected under Schedule I of the Indian Wildlife (Protection) Act 1972
Known to occur at one time but presently not found

APPENDIX IV - PLANTS AND ANIMALS IN THE LAKE USED AS FOOD AND (OR) OF COMMERCIAL IMPORTANCE

A PLANTS

Scientific name	Family	Local Name
Zizania latifolia Griseb Staff	Poaceae	ising kambong
Oryza rufipogon Griff		wainuchara
Imperata cylindrica Linn	"	charoi
Phragmites karka Retz		tou
Erianthus procerus Roxb		singnang
Cynodon dactylon Linn		tingthou
Setaria pallide-fusca Schumach		hup
Saccharum spontaneum Linn		mom
Alpinia galanga Linn Willd	Zinziberaceae	pullei
A. nigra Gaertn		"
Hedychium coronarium Koenig		loklei
Polygonum barbatum Linn	Polygonaceae	yelling
Persicaria chinensis Linn H Gross		yengkhuman
P. perfoliata Linn H Gross		lilhar
Cyperus esculentus Linn	Cyperaceae	kaothum
Nymphaea pubescens Willd	Nymphaeaceae	tharo
N. indica Linn		
N. stellata Willd		thariktha
N. nouchali Burm		
N. lotus Linn		tharo angangba
Nelumbo speciosum Willd		thambal
N. nucifera Gaertn		
Euryale ferox Salisb		thangjing
Trapa natans Var. *bispinosa* Roxb Makino	Trapaceae	heikak
Sagittaria sagittifolia Linn	Alismataceae	koukha
S. sinensis Linn		
Oenanthe javanica (Bl.) Prodr	Apiaceae	komprek
Centella asiatica Linn		peruk
Ipomoea aquatica Forsk	Convolvulaceae	kolamni
Colocasia esculenta Schoot	Araceae	lampal

B ANIMALS

Scientific name	Family	Local Name
Pila globosa Swainson	Cyclophoridae	wainutharoi
Pila species	Cyclophoridae	labuktharoi
Lymnaea stagnalis	Lymnaeidae	tharaoi *angkhabi*
Unio marginalis	Unionidae	kongreng
Caridina species	Palaemonidae	waikhu
Macrobrachium lamarrei		khajing *lamarroids*
M. hendersoni cacharensis		
Palaemon styliferous H M Edw		
Belostoma indicum Lep et Serv	Belostomatidae	naosek
Cybister confusus Sharp Tengbi	Dytiscidae	tharaikokpi
Hydrophilus olivaceous (Fabr.)	Hydrophilidae	tharaikokpi

Source Tombi Singh 1991 & 1992

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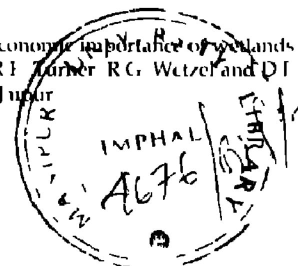
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World Wide Fund For Nature - India

The World Wide Fund for Nature - India (WWF-India), formerly known as the World Wildlife Fund - India was established in 1969 as a Charitable Trust under the Bombay Public Trusts Act of 1950 Today WWF-India is the country s largest conservation NGO with a network of State and Divisional offices spread across the country Its Secretariat is in New Delhi The organisation is part of the WWF family worldwide with 28 other independently registered and autonomously functioning WWF National Organisations A coordinating International Secretariat the WWF International, is located in Switzerland

WWF-India started life as a modest wildlife conservation organisation with a focus on protecting particular species of wild fauna Over the years the perspective broadened to encompass conservation of habitats ecosystems and support to the management of the country s protected areas network In 1989 WWF-India articulated its Mission as follows to suit India s specific ecological and socio-cultural circumstances

The promotion of nature conservation and environmental protection as the basis for sustainable and equitable development

In essence the central goal is the conservation of India's biological diversity through a multi-pronged strategy which stresses community based approaches Most WWF-India programmes are oriented to this

WWF-India completes in 1994 twenty five years of service to the cause of promoting harmony between humankind and nature